# OHT OneHealth Manual

A system to create short and medium term plans for health services

An analytical tool developed to support policy decisions concerning public health and accompanying research

January 2024

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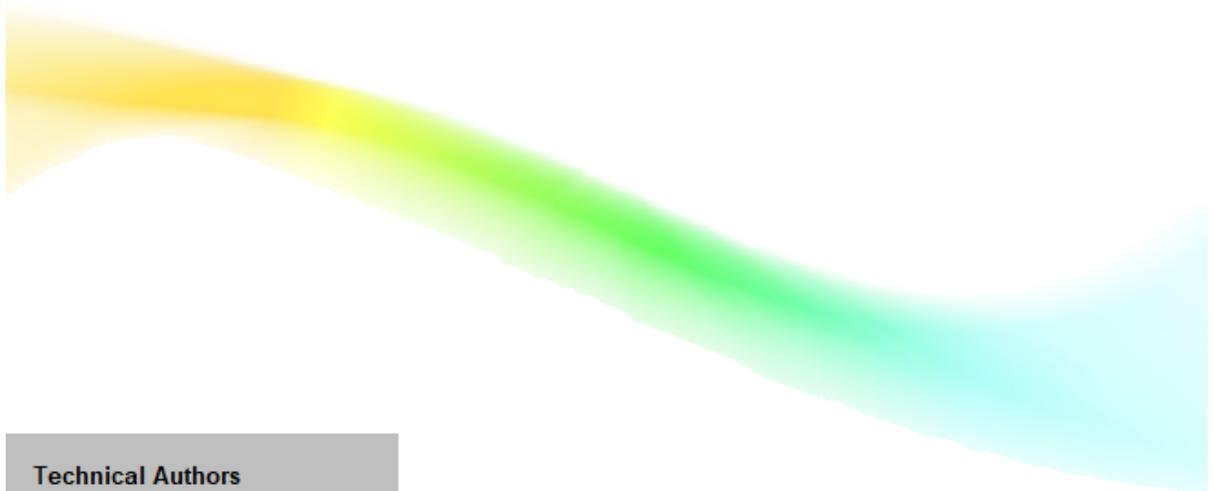
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1.1   Description of the OneHealth Tool

OneHealth is a tool that can be used to inform the development of strategic plans for health sector planning. The software was developed to respond to country requests for a single tool which reflects the best aspects of the existing tools. The OneHealth tool provides a unified framework to strengthen integrated planning. OneHealth is a single mechanism to be used for supporting the planning, costing and budgeting of health sector priorities, including health system strengthening strategies. As such it represents a modular instrument for program-specific and sector-wide applications. The tool illustrates the health system implications of scaling up intervention delivery, shows the capital investment gap and allows a comparison of costs with the estimated financial resources available. In this manner, the tool facilitates scenario generation and informs priority setting processes. The identification of impediments to intervention scale-up emphasizes the need to strengthen systems for sustainable long term planning.

The tool facilitates an assessment of costs related to the areas of maternal, newborn and reproductive health, child health, vaccination, malaria, tuberculosis, HIV/AIDS, nutrition, and water sanitation and hygiene, to inform progress towards the Millennium Development Goals, including assessment of achievable health impact. In addition it contains modules for the areas of human resources, infrastructure, logistics, financial space, programme and channel analysis, intervention coverage and costing, bottleneck analysis, programme costing, summary outputs and budgeting.

Potentially, OneHealth has a multiplicity of users. At the most comprehensive, health planners putting together a multi-year health plan can use the tool to create a costed plan for addressing critical health needs in a country; to compare different scenarios for reaching the identified health sector priority goals. This could be as part of a national strategic health planning exercise or as a part of a proposal to a multi-lateral funding organization. At a simpler level, disease area planners can use the programme planning modules to develop plans addressing their particular needs with reference to health systems as appropriate. Similarly, health systems planners can use the systems modules to make medium and long range plans for Human Resources, Infrastructure, Logistics, etc. as appropriate. The added value of OneHealth is generated when multiple modules are used at the same time, to identify synergies and to ensure that planning processes take into account systemic constraints.

1.2   Description of modules

Impact Modules

- **DemProj** *Demography*. DemProj projects the population for an entire country or region by age and sex, based on assumptions about fertility, mortality, and migration. A full set of demographic indicators can be displayed for up to 100 years into the future. Urban and rural projections can also be prepared. Default data needed to make a population projection is provided from the estimates produced by the Population Division of the United Nations. DemProj is a required module for all projections created in OneHealth since its population projection is utilized by most of the calculations in the other modules.

- **FamPlan** *Family Planning*. FamPlan projects family planning requirements needed to reach national goals for addressing unmet need or achieving desired fertility. It can be used to set realistic goals, to plan for the service expansion required to meet program objectives, and to evaluate alternative methods of achieving goals. The program uses assumptions about the proximate determinants of fertility and the characteristics of the family planning program (method mix, source mix, discontinuation rates) to calculate the cost and the number of users and acceptors of different methods by source.

- **AIM** *AIDS Impact Model*. AIM projects the consequences of the HIV epidemic, including the number of people living with HIV, new infections, and AIDS deaths by age and sex; as well as the new cases of tuberculosis and AIDS orphans. AIM is used by UNAIDS to make the national and regional estimates it releases every two years.

- **Goals**: The Goals Model helps efforts to respond to the HIV/AIDS epidemic by showing how the amount and allocation of funding is related to the achievement of national goals, such as the reduction of HIV prevalence and expansion of care and support. This model explores also the impact of potential HIV vaccines on the epidemic.

- **LiST** *Lives Saved Tool (LiST- Child Survival)*. A program to project the changes in child survival in accordance with changes in coverage of different child health interventions.

- **RAPID** *Resources for the Awareness of Population Impacts on Development*. RAPID projects the social and economic consequences of high fertility and rapid population growth for such sectors as labor, education, health, urbanization, and agriculture. This program is used to raise policymakers' awareness of the importance of fertility and population growth as factors in social and economic development.

- **RNM** *Resource Needs Model*. This model is used to calculate the funding required for an expanded response to HIV/AIDS at the national level. It estimates the costs of implementing an HIV/AIDS program, including costs for care and treatment, prevention programs, and policy and program support.

- **TIME** *TB Impact Module and Estimates*. The TIME Estimates module provides the user with smoothed estimates of historical and current TB incidence and notification as well as short term statistical projections. Results are stratified by treatment history, smear and MDR status based on data from the WHO Global TB Database. The module can calculate TB/HIV incidence and mortality using UNAIDS estimates on HIV prevalence, CD4 distribution and ART coverage. TIME Estimates results are used to calculate TB program costs in One Health, and serve as historical data points for calibration in the TIME Impact module. The TIME Impact module allows users to generate short and long term projections of TB incidence and notification for their population of interest, and assess the epidemiological impact of a variety of user-defined interventions. Results of TIME are used to generate cost-effectiveness estimates of interventions using One Health.This model projects the consequences of incident TB, including the number of cases notified for treatment, the number of multiple-drug resistant cases and the number of deaths due to TB. It further projects deaths averted in accordance with increasing case detection.

- **NCD**: The non-communicable disease impact module calculates the populations affected by, and the impact of scaling up interventions on cardiovascular and respiratory disease, diabetes, cancer, and mental health, neurological, and substance abuse disorders.

OneHealth Tool Modules

- **OneHealth - Configuration**: The OneHealth Configuration allows for the configuration of elements used within multiple OneHealth modules, such as interventions, staff, facilities, currency, and exchange rate.

- **Human Resources**: The Human Resources module allows the costing of salaries, benefits, and incentives for health service providers and health management and support personnel as well as pre-service training and non-specific in-service training.

- **Infrastructure**: All facilities providing medical interventions, as well as most facilities offering support functions, are planned for and costed within the Infrastructure module. The Infrastructure module also includes planning functions for equipment, furniture, vehicles, and communication.

- **Budget Mapping**: The Budget Mapping module can be used to allocate intervention and health system costs across budget categories established by the user, in order to match country or international institution cost categories.

- **Governance**: The governance module includes costing templates for assessing the costs of governance activities.

- **Logistics**: The Logistics module allows for the planning of warehouses and vehicles needed to move commodities/drugs and supplies from central warehouses to the endpoints of a logistics system. It is also where planning for commodities/drugs and supplies that are not included in the Intervention costing module is done.

- **Health Financing**: The Health Financing module is used to estimate the costs of implementing health financing programs such as vouchers, subsidies, or cash transfers.

- **Financial Space**: The Financial Space module is used to analyze the financial space within which health plans are expected to be executed.

- **Health Information Systems**: The Health Information Systems (HIS) module includes costing templates for assessing the costs of implementing a health information system..

1.3   Software options

Language

Changes the application strings to the selected language. This will also initiate a prompt to download (Internet connection required) a language specific help file if needed and available. If help is not available in the selected language, OneHealth will use the English version of help.

Editor/display font

Determines which font is used in the input editors and result displays. You may want to change from the default font if characters are not showing correctly with the selected language.

Enable OneHealth Layout

Spectrum and the OneHealth Tool use a common code base. When checked, the OneHealth Tool layout is applied to the interface.

Color scheme

Select color scheme of your choice.

Hint duration

Determines the amount of time in seconds a hint or hover text will appear on the screen when active. Moving the slider to right most position will invoke a setting of infinite which is useful for reading larger hints. Under any setting, mouse movement or a key press will close the hint box. Hints are activated by positioning the mouse pointer over a display element and holding. This is most applicable in the input editors when comments are used to describe cell contents.

Show welcome tab

Determines if the welcome tab is shown when OneHealth starts.

Prompt before re-projection

If checked, OneHealth will prompt before re-projecting. This is primarily a debugging tool and is recommended to be left unchecked.

Save projection manager defaults

When checked, the latest settings in projection manager will become the defaults for the next visit. Useful when creating multiple projections which have similar characteristics, such as projecting years and country.

Copy editor values with full precision

Values in the input editors are formatted to a specified precision for display readability. When checked, the unformatted (full precision) values are copied to clipboard. This is useful when copying values internally between editors since the calculation routines use the full precision numbers saved from the editors which may differ slightly from the formatted value.

Copy result values with full precision

Values in the result tables are formatted to a specified precision for display readability.   When checked, the unformatted (full precision) values are copied to clipboard. Since results are primarily copied to an external application such as Excel, the recommended setting is unchecked to preserve the data format and readability of the values.

1.4 Uses of the policy models

Policy models are designed to answer a number of "what if" questions relevant to entities as small as local providers of primary health care services and as large as international development assistance agencies. The "what if" refers to factors that can be changed or influenced by public policy.

Models are commonly computerized when analysts need to see the likely result of two or more forces that might be brought to bear on an outcome, such as a population's illness level or its degree of urbanization. Whenever at least three variables are involved (such as two forces and one outcome), a computerized model can both reduce the burden of manipulating those variables and present the results in an accessible way.

Policy issues commonly addressed by the OneHealth set of models

- The utility of taking actions earlier rather than later. Modeling shows that little in a country stands still while policy decisions are stalled, and that many negative outcomes can accumulate during a period of policy stasis.

- The evaluation of the costs vs. the benefits of a course of action. Modeling can show the economic efficiency of a set of actions (i.e., whether certain outcomes are achieved more effectively than under a different set of actions), or simply whether the cost of a single set of actions is acceptable for the benefits gained.

- The recognition of interrelatedness. Modeling can show how making a change in one area of population dynamics (such as migration rates) may necessitate changes in a number of other areas (such as marriage rates, timing of childbearing, etc.).

- The need to discard monolithic explanations and policy initiatives. Modeling can demonstrate that simplistic explanations may bear little relationship to how the "real world" operates.

- The utility of "door openers." A set of policies under consideration may not be acceptable to all stakeholders. Modeling can concentrate on favored goals and objectives and demonstrate how they are assisted by the proposed policies.

- That few things in life operate in a linear fashion. A straight line rarely describes social or physical behavior. Most particularly, population growth, being exponential, is so far from linear that its results are startling. Modeling shows that all social sectors based on the size of population groups are heavily influenced by the exponential nature of growth over time.

- That a population's composition greatly influences its needs and its well being. How a population is composed in terms of its age and sex distribution - has broad-ranging consequences for social welfare, crime rates, disease transmission, political stability, etc. Modeling demonstrates the degree to which a change in age and sex distribution can affect a range of social indicators.

- The effort required to "swim against the current." A number of factors can make the success of a particular program harder to achieve; for example, the waning of breastfeeding in a population increases the need for contraceptive coverage. Modeling can illustrate the need for extra effort - even if simply to keep running in place.

1.5 More information

Spectrum Install File and Manuals:

Click the Health Policy Plus or Avenir Health link below in order to download the latest Spectrum install file or detailed documentation in several languages:

Health Policy Plus website

Avenir Health website

Follow Spectrum on Twitter and YouTube:

LiST: The Lives Saved Tool:

Specific information pertaining to LiST can be found at the following link:

The Lives Saved Tool – software that predicts survival of mothers and children

OHT: OneHealth Tool:

Specific information pertaining to OHT can be found at the following link:

International Health Partnership

Avenir Health:

For general questions, information or application support, please contact Avenir Health using either of the links below:

Avenir Health website

ModelSupport@AvenirHealth.org

1.6 Software support

To view the online Knowledge Base - Wiki for OneHealth click the following link:

Online Knowledge Base

Use the following link to submit a request for support:

Submit a request

1.7 System requirements

Spectrum is a 32 bit PC application which is designed to run on Windows XP and greater. 2GB RAM along with 5GB of free hard disk space is recommended for installation and operation of Spectrum.

2 Using Projections

2.1 Create a new projection

In OneHealth, a projection is defined as a group of modules linked together for the purpose of integrated calculations and display results. You can create a new projection in two ways.

1. When Spectrum is open you can click on "New projection" under **Getting started** on the **Welcome** tab.
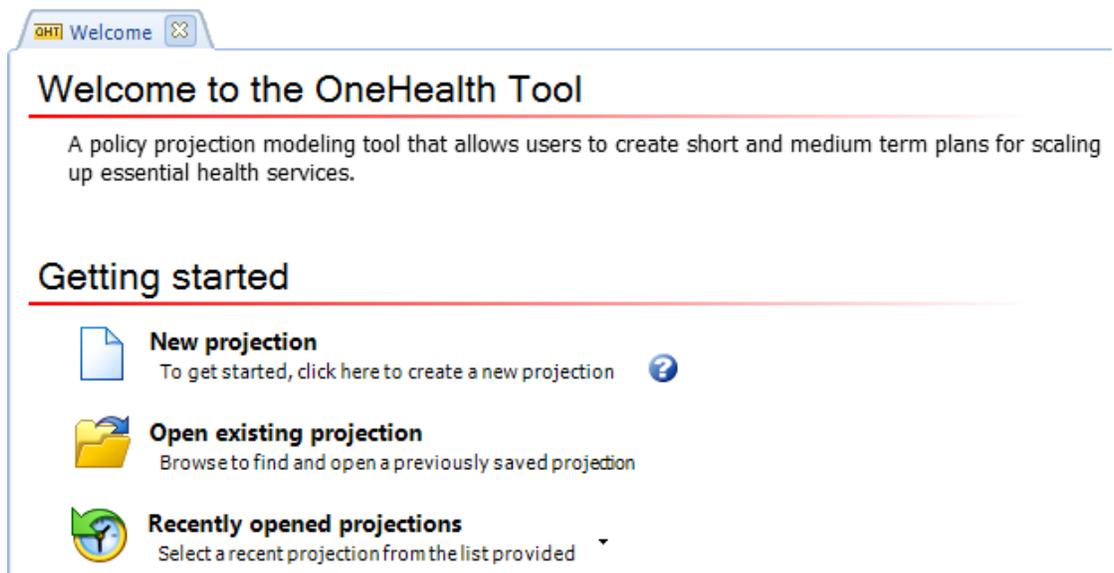
2. Select the **Home** tab, click on "New".
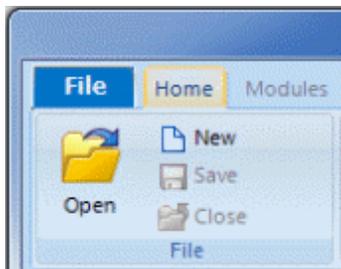
In both cases you will see the **Projection manager** dialogue box.

The following information is displayed:

Projection file name   :   This is the name and path for the data files associated with this projection. This name is also used to identify the projection across the Spectrum user interface.

First year   : This is the first year of the projection.

Final year   : This is the final year of the projection.

Active modules   : The check boxes let you select other modules that will be used with the population projection.

Country data   : This is where you can select the country associated with default data for active modules.

Sample set-up process:

1. In the Projection manager dialogue box, click the "Projection file name" button, enter a file name for the projection, then click "Save". Enter the first year of the projection and the last year of the projection.

2. Activate modules of your choice by checking the appropriate box. Some modules are dependent on others such as Goals dependency on AIM. Projection Manger will ensure that dependent modules are activated by automatically selecting dependents as needed. Demproj is a required module and cannot be unselected.

3. Click the "Default data" button and select your country or global region from the list. If your country is not shown, additional countries may be downloaded using the download button. An Internet connection is required for this process.

4. Once you click "Ok" from Projection Manager, Spectrum will create the projection and load any default data available.

2.2   Edit an existing projection

Adding or deleting of modules in a specific projection occurs in the Projection Manager. To edit a projection, click on the **Home** tab on the top menu, and then click "Projection Manager".
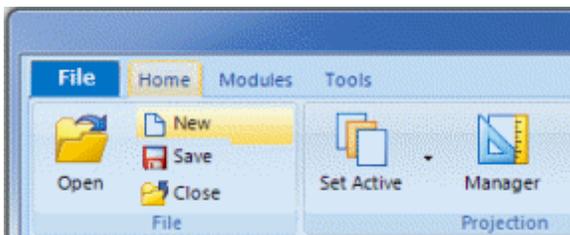
When the **Projection manager** dialogue box appears, changes to the projection can be made. Click "Ok" to save changes, click "Cancel" to exit without changes.

2.3 Reload country specific default data for an existing projection

At times it is necessary to reload specific default data in order to reset the projection. Note: this will delete previously entered data in favor of the defaults.

Click the **Home** tab on the top menu, click "Projection Manager", then click "Default data".
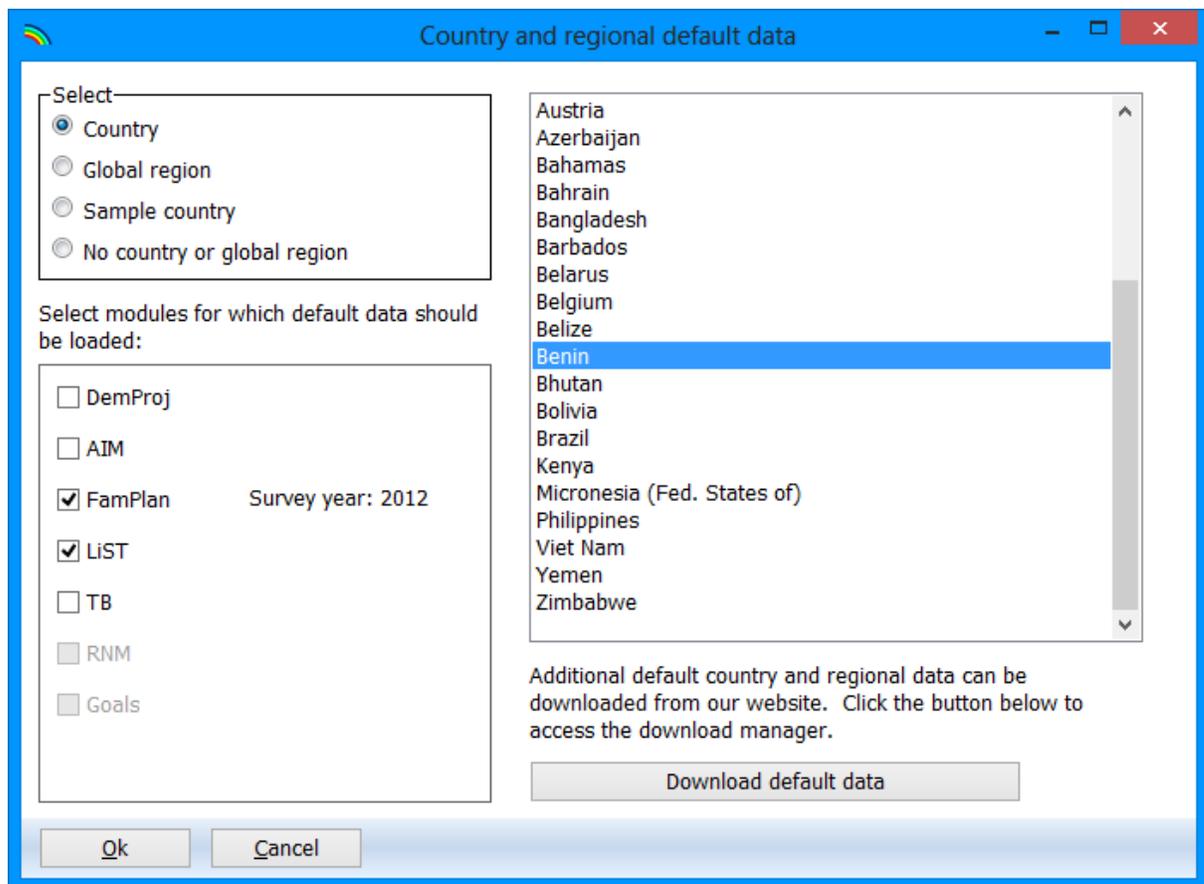
The selected country is highlighted in blue. In this case the selected country is Benin. The checkboxes on the bottom left indicate which selected modules have country specific data available. To reload the country specific data for a particular module, check that module. In this case, FamPlan and LiST have been checked indicating data for those modules will be reloaded for this projection. Click "Ok" and again in Projection Manger to reload the default data and save all changes.

2.4 Set active projection

You can determine if a particular projection is active by looking at the top of the OneHealth window. The file name of the active projection will be displayed above the menu bar. In this case *ProjectionOne* is the active projection. If you only have one projection open it is automatically the active projection. To determine how many projections are open look at the very bottom of the OneHealth window. In this case, *ProjectionOne*, is the only projection open.
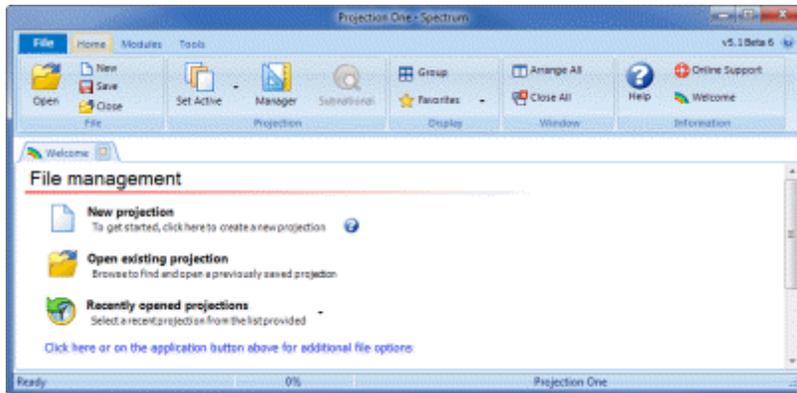
If you have more than one projection open, all projection file names will be displayed at the bottom of the OneHealth window as shown in the picture below. To determine which projection is active, look at the top of the Spectrum window. The active projection file name will be displayed. The active projection file name will also be in bold and have a * next to it in the file list at the bottom of the window. In this case, *ProjectionThree*   is the active projection.
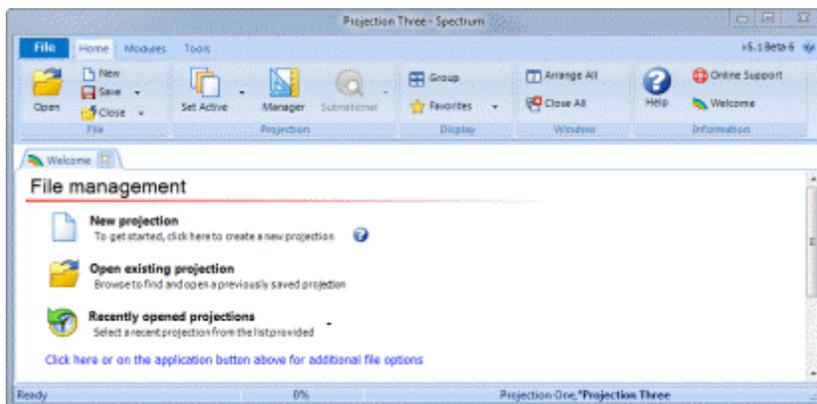
To select another projection to be set as active, use the **Set Active** button in the menu bar or click on the appropriate file name in the status bar.

2.5   Set a projection file name

Select and set a name and folder location for your projection data. The projection files will be saved in your chosen location with a '.pjnz' extension.

2.6   Set year boundaries

Spectrum Layout/Mode

The first year of a Spectrum projection can fall anywhere between 1970 and the current year + 1, inclusive, and defaults to the current year. The final year of a Spectrum projection can fall anywhere between the year after the selected first year and 2070, inclusive. See here for more information about specific module considerations such as AIM and Goals. (Link to activate modules page)

OneHealth Tool Layout/Mode

The first year of a OneHealth projection can fall anywhere between 1970 and the current year + 1, inclusive, and defaults to the current year. The final year (of the costing modules) for a OneHealth projection can fall anywhere between the year after the selected first year and 2070, inclusive, and defaults to five years after the current year. The user can extend the final year of health systems modules by checking the "Extend final year for health systems modules" checkbox and changing the year dropdown that becomes enabled. The final year of the health systems modules cannot be less than the final year of the costing modules. The first and final year of the impact modules is automatically set to the same year as OneHealth.

2.7   Activate modules

Activate the modules you would like to use in your projection. Selected modules will be enabled for this projection. If multiple projections are open they must have the same modules activated with the exception of TB and NCD which can be mixed as required.

Click here for more information on each module.

AIM Module (special considerations)

AIM must start its calculations prior to the first year of the epidemic in order to model the HIV progression properly. OneHealth however will allow the selection of any valid start year when using the AIM module. For projections requiring fine tuning of early epidemic years, it is recommended to use a First Year setting of 1970 which follows the start year for most standard UNAIDS projections. For more general applications where AIM is being used in conjunction with other modules or OHT, a more recent year may be the better choice. See CalcState section below for more details.

Goals Module

In addition to the AIM requirement above, Goals must use a first year of 1970 in order to load pre-

calibrated Goals data for select countries.

CalcState

A projection starting in 1970 may present an unnecessary input burden for OHT or other modules when used in conjunction with AIM. Therefore OneHealth allows a first year setting greater than 1970 using the CalcState feature. This is useful for country applications where data may be available from a recent survey which can be used for the projection's baseline inputs.

As an example, OneHealth will activate with AIM and allow the selection of 2010 for a projection. Now first year population numbers in 2010 can be entered along with other inputs. What OneHealth does in the background is create a temporary projection from 1970 to 2010 and generates the HIV "state" for successive projections.   OneHealth will adjust the population, TFR and HIV inputs as needed in the temporary projection to properly match the 2010 inputs supplied and generate the correct HIV "state" for AIM. This only has to be done once unless you change your baseline assumptions. The CalcState feature does not need to be turned on, it will activate as needed in the background.

2.8 Select a country

Select a country from which to retrieve demographic and other default data.

Country specific data

Choosing a country populates the projection with country specific data. Demographic (DemProj) data are based on estimates and projections of the United Nations Population Division, and is available for all countries shown. LiST data are collected by Child Health Epidemiology Reference Group (CHERG) but is not available for all countries. FamPlan data are the latest DHS for each selected country, it is also not available for all countries. In addition Spectrum now will load data on HIV incidence, and number of people receiving ART, cotrimoxazole and PMTCT services based on data published by UNAIDS and WHO. It is important that users compare these inputs with their program data and make any revisions that might be necessary. In particular, the data provided on PMTCT services should be reviewed. If your country is not shown in the selection dialog, additional countries may be downloaded using the download button. An Internet connection is required for this process.

Subnational projections

Check the "Subnational projection" checkbox if you would like to implement a subnational region analysis.   Once checked, you will be offered the option to specify a subnational region name. This name is a useful identifier for particular outputs such as the Extract tool.   Although there is no subnational default data, it is also recommended that you select a country in order to load national default data. This will create a working projection which is more easily tailored to your specific regional needs.

3   File Management

3.1   Open an existing projection

You can open an existing projection in several ways.

1. You can open a recently loaded projection from the list shown on the **Welcome** tab. To see the list, click "Recently opened projections". A drop down menu of the most recent projections will appear. To open one of these projections, simply click on it. The selected projection will open in the OneHealth window. If the projection you need is not in "Recently opened projections", you can click on "Open existing projection" and browse to choose a projection.
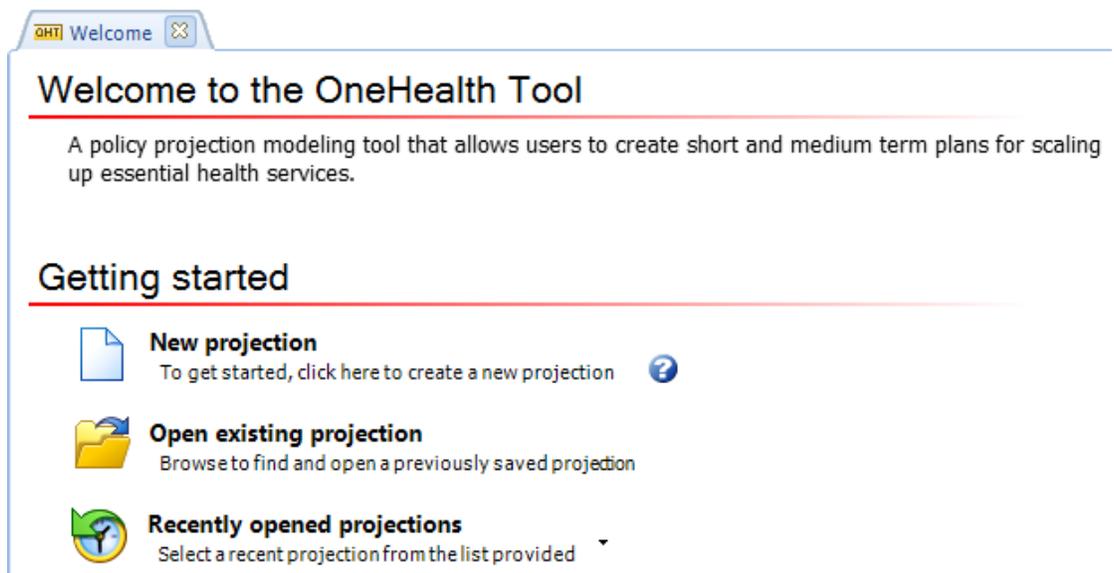
2. To open an existing projection you can also select the **Home** tab and click on "Open". A window will open so that you can navigate to the directory where the desired projection is located. You can also click on the **File** tab in the upper left corner of the OneHealth window.
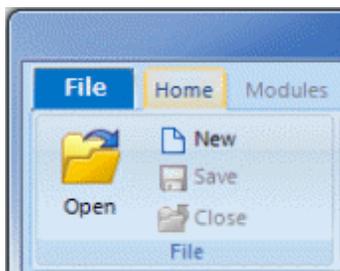
3. When the **File** tab is clicked, a drop down menu appears. To select a projection, click "Open projection" and browse to the desired projection. You can also click on one of the projections listed under **Recent projections** on the top right side of the drop down menu.
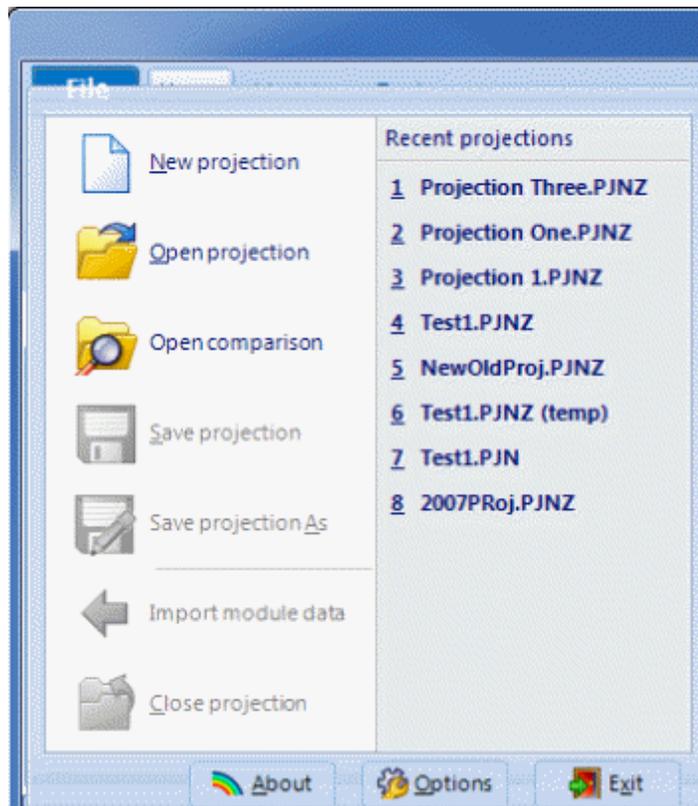
3.2   Add a module to an existing projection

This example will show how to add modules to a previously prepared demographic projection:

1. If the projection is not currently loaded, you will need to select the projection file from the "Open" dialogue box and press "Ok."

2. Once the projection is open, select "Manager" on the Projection group of the OneHealth menu.

3. You will see the Projection manager dialogue box where you can activate modules of your choice. Default data for the newly added modules will be loaded automatically. Existing module will not reload default data by default. These options can be modified in the default data selection dialog.

4. Click "Ok" to complete the set-up process.

5. You can then go to the Modules tab of the OneHealth menu and begin working in newly activated modules.

3.3   Save a projection

There are several ways to save a projection.

1. Click on the **Home** tab on the top menu, then click "Save". You can also click on the **OneHealth Icon** in the upper left corner of the OneHealth window.
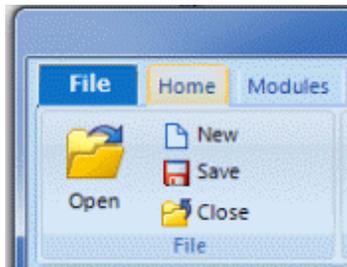
2. When the **File** tab is clicked, a drop down menu appears, click "Save projection" to keep the same projection name and location. You also have the option to click "Save projection As" in the drop down menu. Use this option if you want to change the projection name, where the projection file is saved or both.
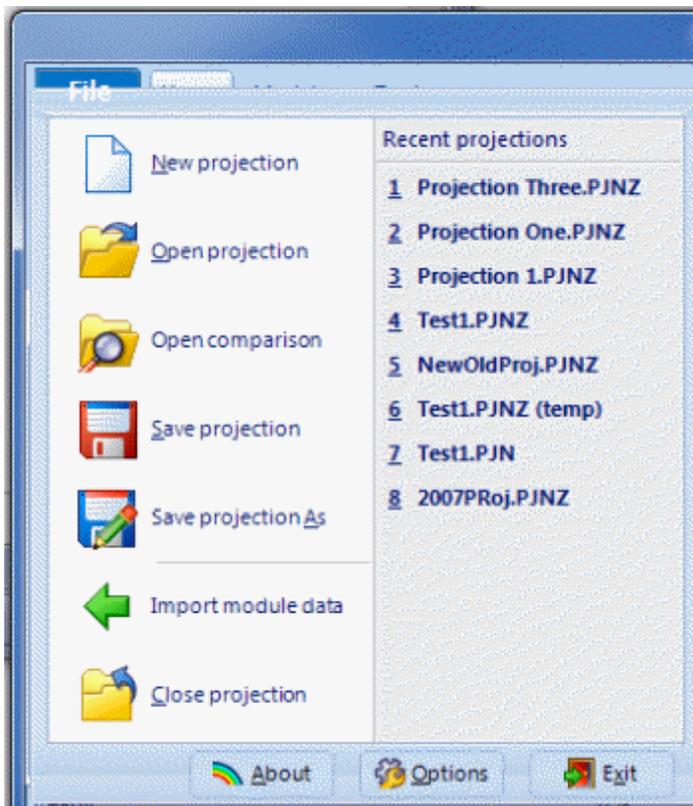
If more than one projection is open and you click "Save", a drop down menu of all open projections will appear. You can select the projection you want to save by clicking the projection name. When you want to save all open projections with the same names you could also select "All projections" rather than clicking them individually.
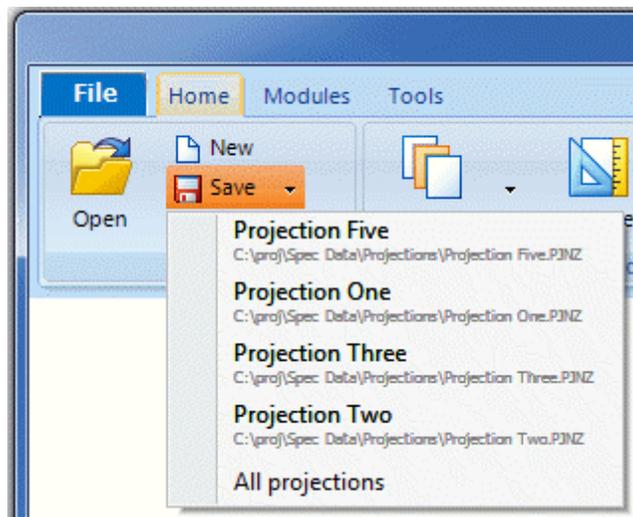
If you choose "Save Projection As" in the drop down menu the **Select projection** dialogue box will appear. You can save a single projection by either double clicking the projection name or selecting the projection and clicking "Ok". To save all projections either double click "All projections" or select "All projections" and click "Ok".
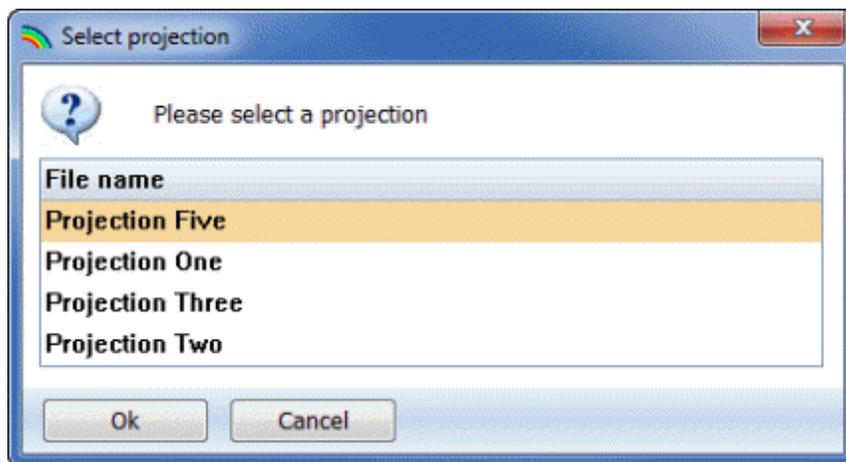
3.4   Close a projection

There are three ways to close a projection.

1. Click on the red X tab in the upper right corner of the OneHealth window. Note that if you choose this option, all open projections will close.

2. Click on the **Home** tab on the top menu, then click "Close".
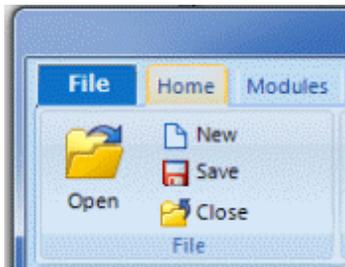
3. Click on the **File** tab in the upper left corner of the OneHealth window.
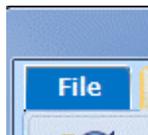
When the **File** tab is clicked, a drop down menu appears, click "Close projection" to close the file.
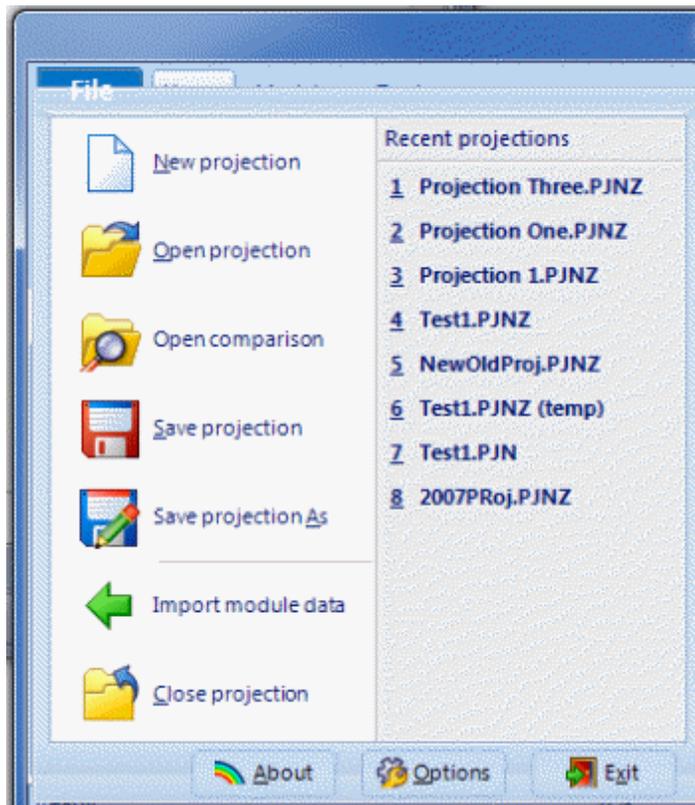
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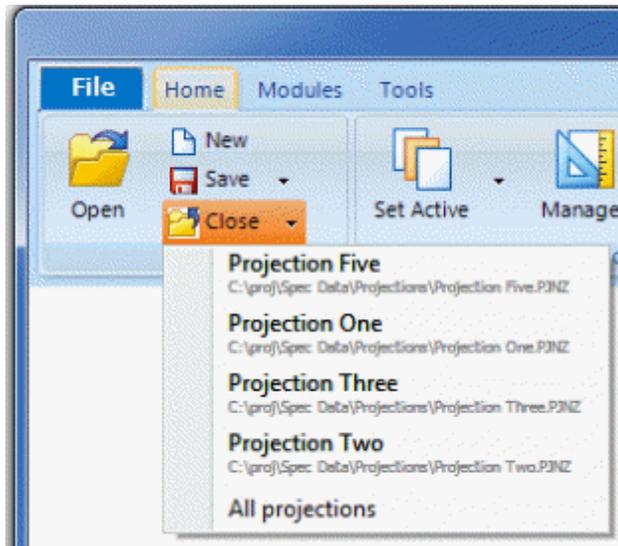
If you choose "Close projection" in the drop down menu the **Select projection** dialogue box will appear. You can close a single projection by either double clicking the projection name or selecting the projection and clicking "Ok". To close all projections either double click "All projections" or select "All projections" and click "Ok".
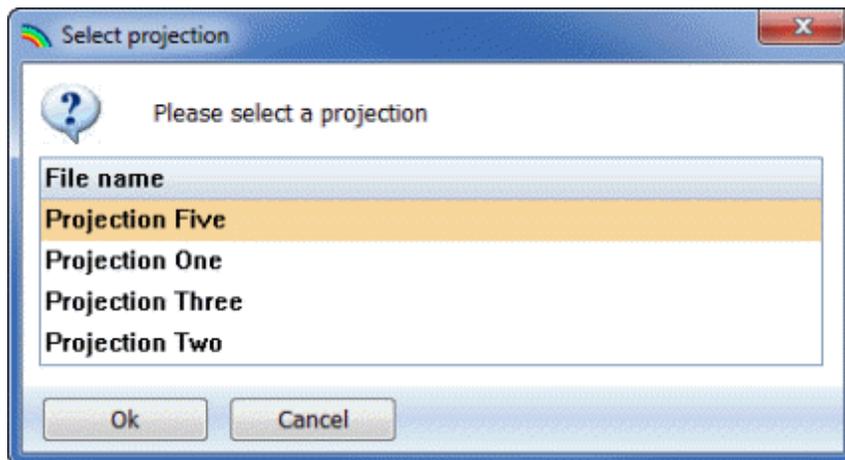
4   Using Modules

4.1   Edit module data

To edit a module in a projection, click the "Modules" tab on the menu bar. All active modules will be shown. In this case Demproj and AIM are the active modules.
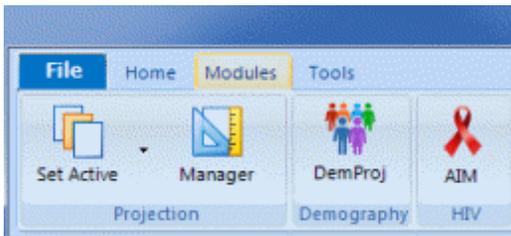
To edit a specific module's data, click that module in the menu bar. The edit menus and results menu will be displayed in a menu bar directly below the module names. In this case DemProj was selected. There are similar editor/results menu bars for each module.

Once you click on one of the menu items, the corresponding editor will be displayed. Below is the DemProj editor for "Demographic data".
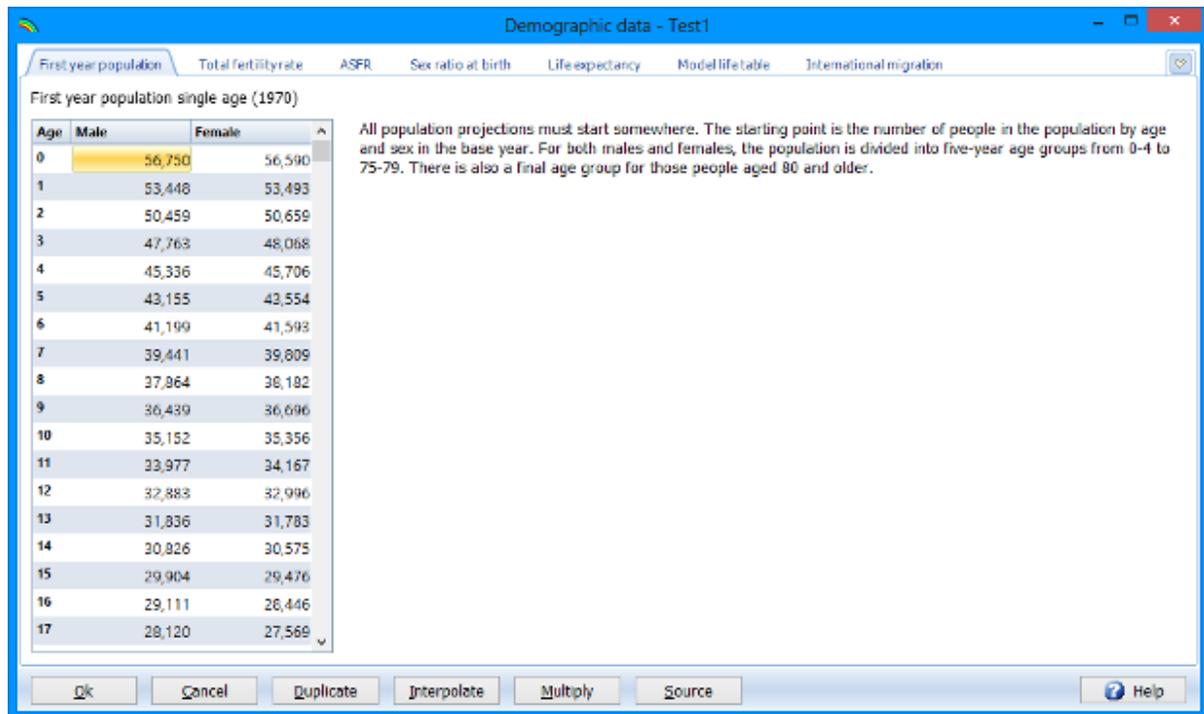
If you "Right click" on an editor you will see edit options as shown in the picture below.
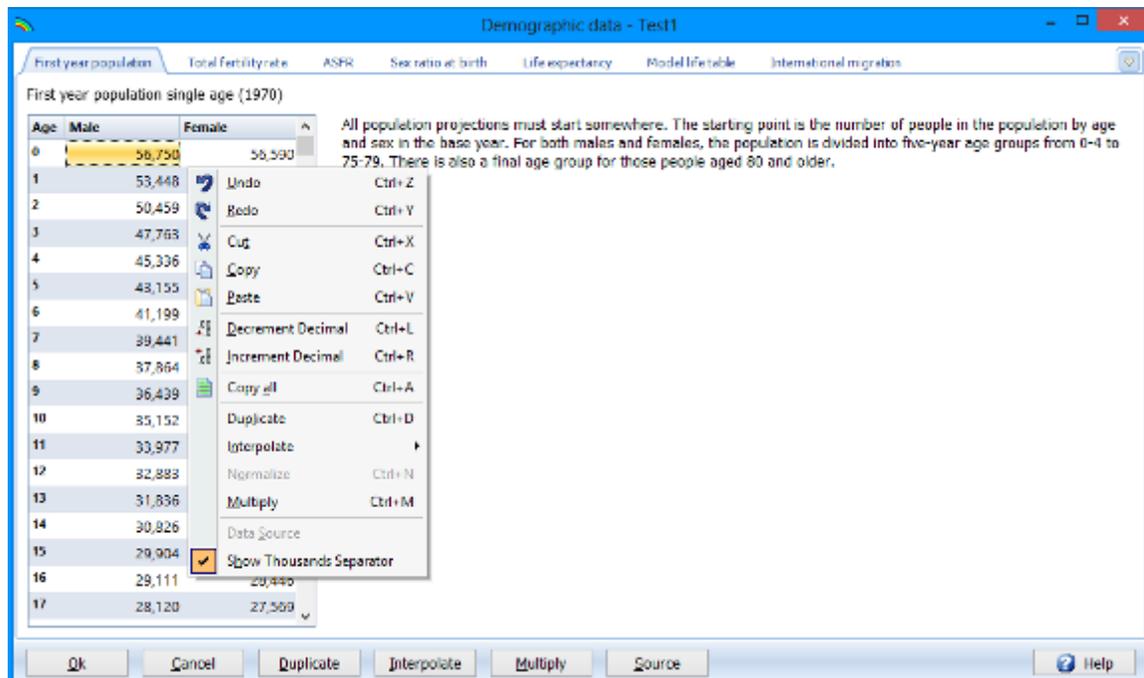
4.2 Source button
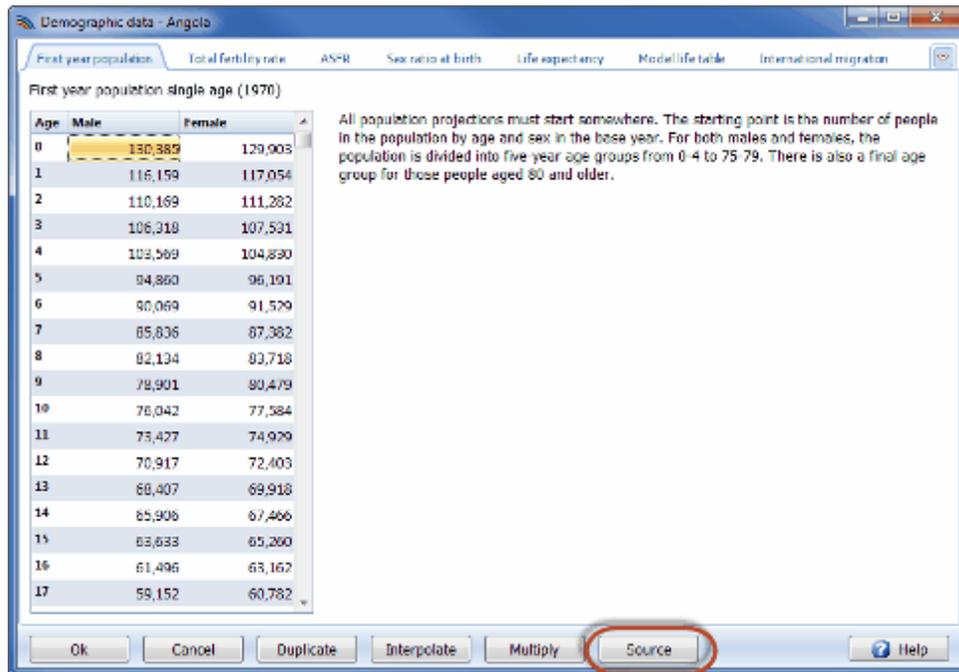
To use the "Source" button

1. Click on the "Source" button to view default source information regarding the data contained in the editor. Once the source window is open, you can add your specific notes by clicking on the window.

2. Enter the source of the data and make any special comments about the assumptions.

3. Click on "Close" to return to the editor.

The "Source" feature allows you to keep a record of the data sources and assumptions as you make the projections. This source information will be maintained with the data file. It is **strongly** recommended that you use this feature to avoid later confusion.

4.3 Calculate the projection

Spectrum keeps track of the validity of a projection depending on changed data or assumption of a loaded projection. Should a calculation be necessary it will occur before a result is displayed. Calculations may take only a few seconds if you are making only a population projection, or could take somewhat longer if you have additional modules activated. The calculation will only occur as needed depending on when data was changed. Under OneHealth Options, you will find a selection to ask OneHealth to prompt the user for confirmation before each calculation.

4.4 Display module data

To display data for a module in a projection, choose the "Modules" tab and select one of the active modules, such as DemProj. Click "Results" in the menu shown directly below the module names. A drop down menu appears showing available indicators.
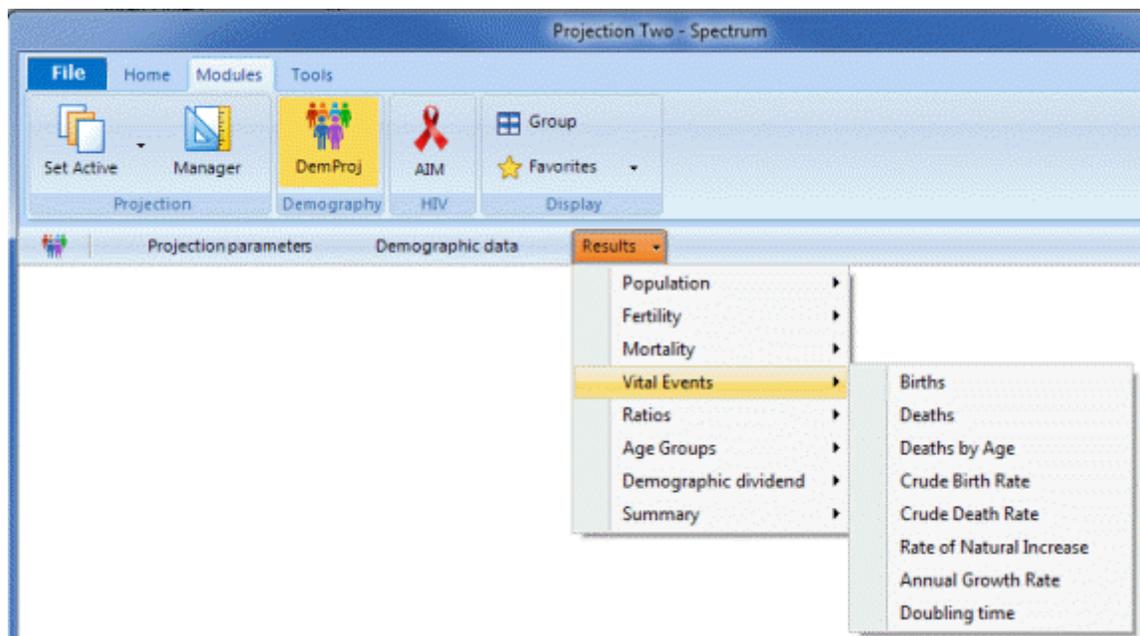
After an indicator is selected, the **Configure** dialogue box appears, it provides several choices on how the data are to be displayed. In this case the dialogue box is shown for Results --> Vital Events --> Births.
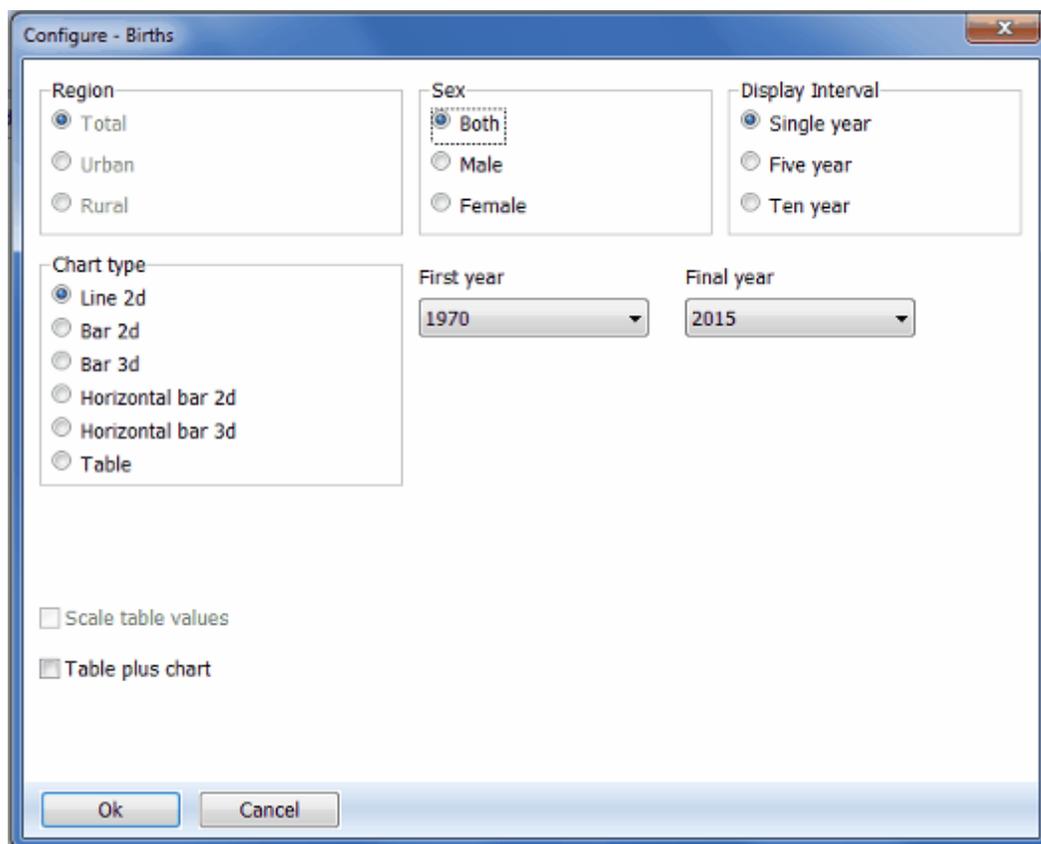
Once the options are selected on the **Configure** dialogue box, click "Ok" and the data will be displayed. To change the configuration, click on "Configure" and the **Configure** dialogue box will appear so you can make desired changes.
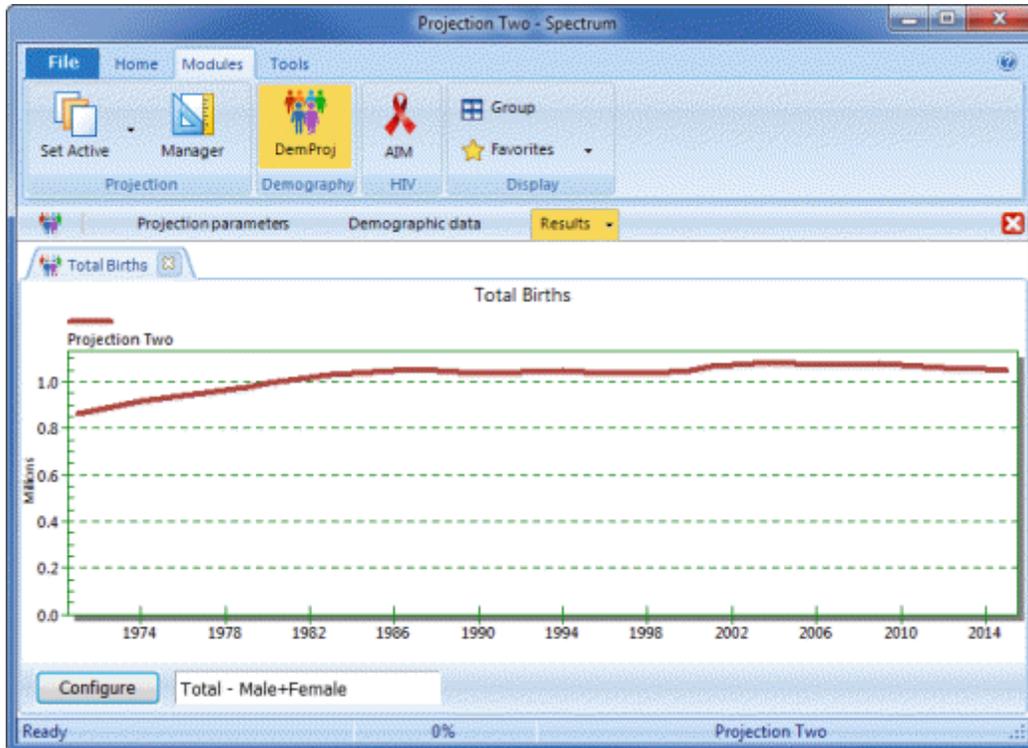
If you "Right click" on a display, you will see the options shown in the picture below.
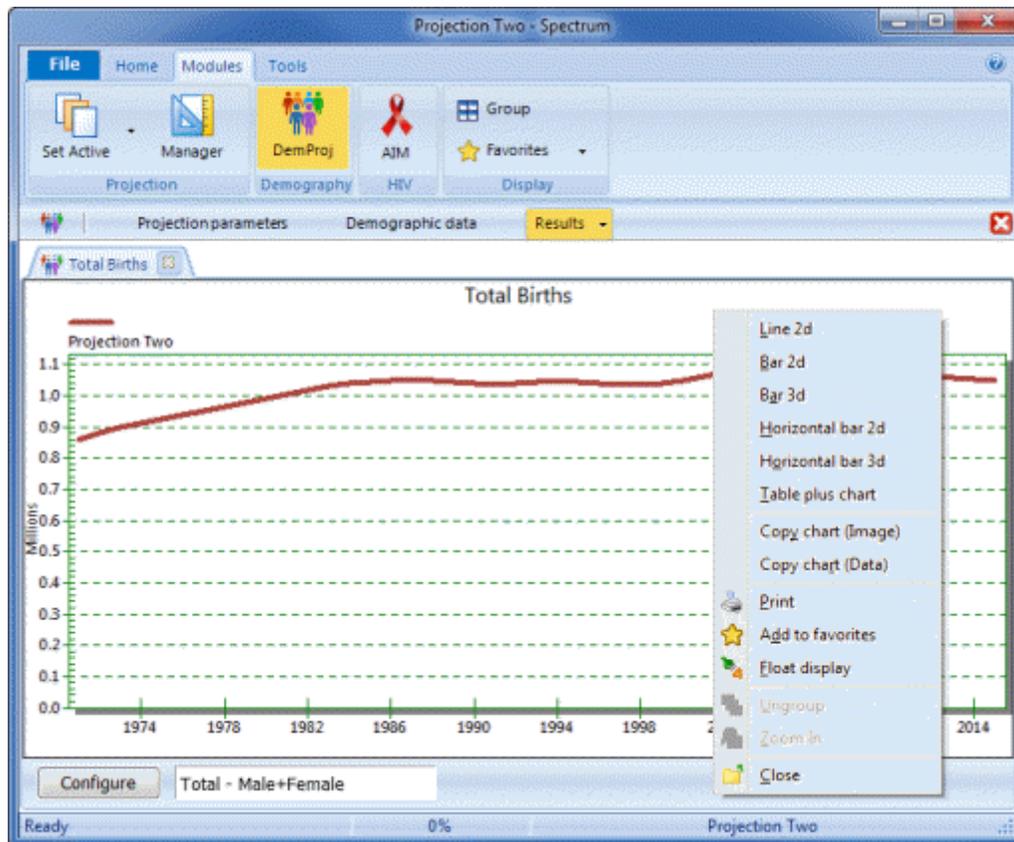
One of the options is "Float display". Float frees the displayed graph/chart/table so that it is separated from the OneHealth window and can be moved anywhere on the computer's desktop. Below is an example of four displays that have been floated.
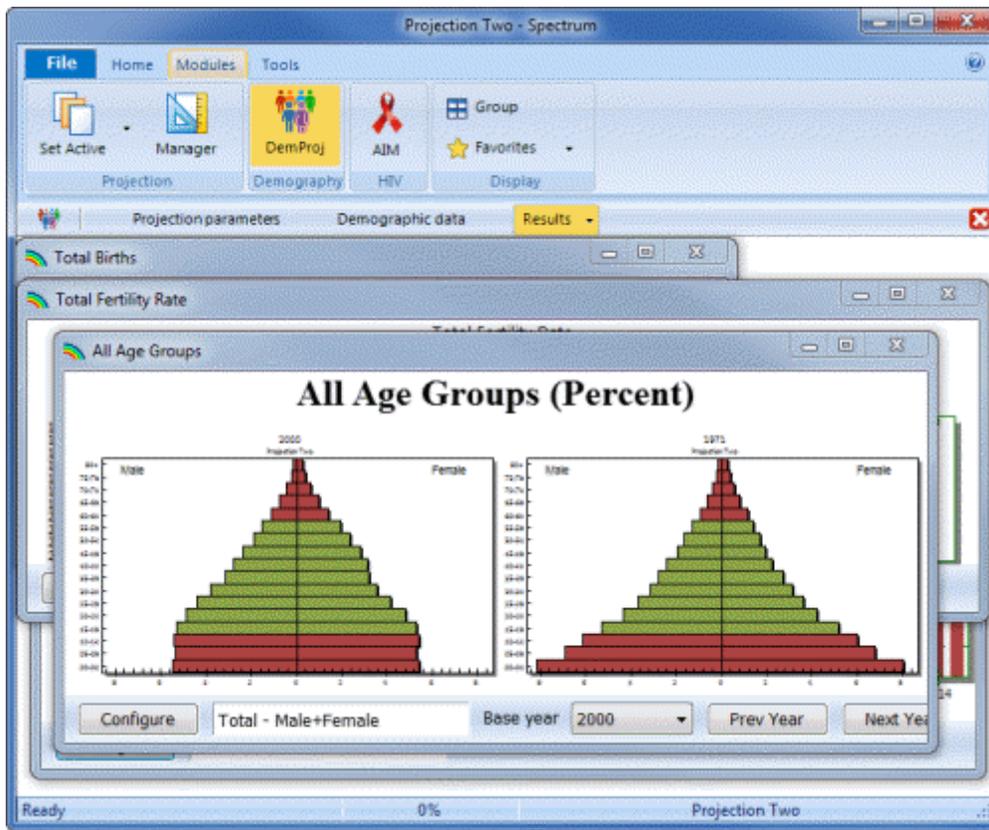
A display can also be docked back to the Spectrum window. If you "Right click" on a floating display you will see that "Dock display" has been added to the options. In the picture below, one of the floating displays from the above example has been docked.
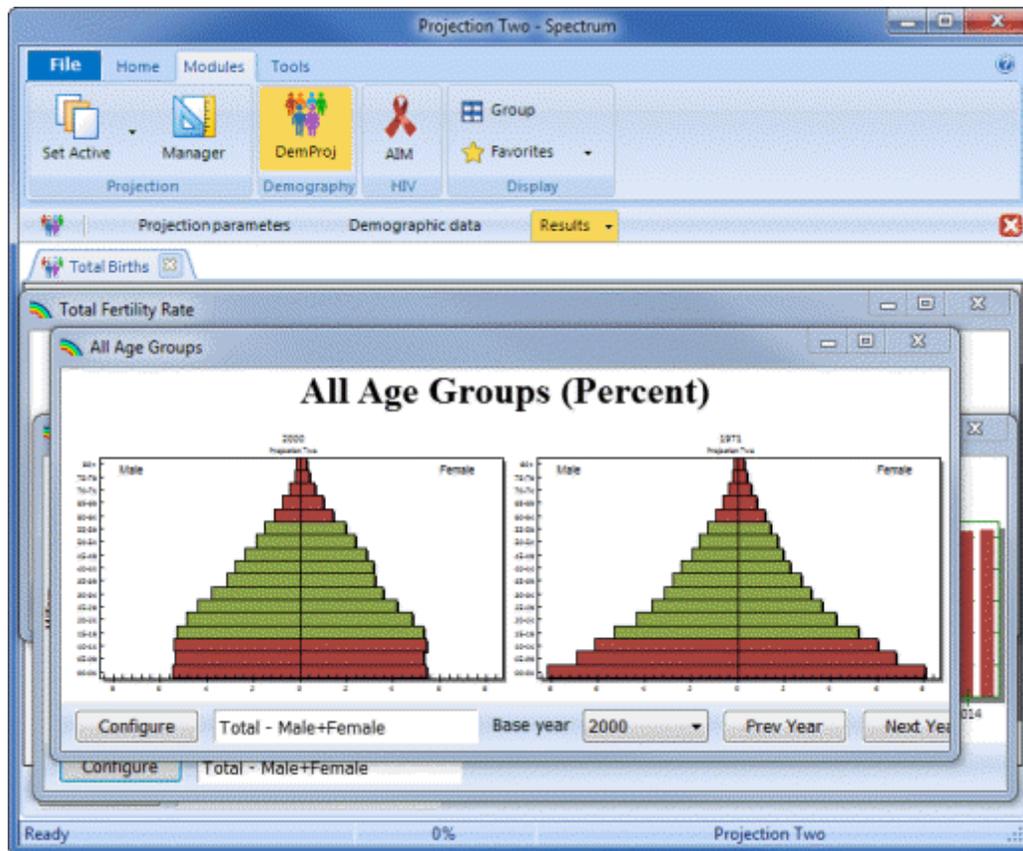
To make it easier to view all of the displays, you can arrange all of the floating displays in an organized manner, by clicking the "Arrange All" button on the **Home** tab. Once you are finished with the displayed data, you can close each display individually or you can click the "Close All" button on the **Home** tab.

4.5 Configure results

1. The exact display choices available will depend on the indicator you have selected. The display will normally be in single years but you can change it to display every five or ten years if desired. The chart type is also set through this dialogue box. Click on the button next to the type of display you want. For LiST, you may also select the age cohort to display for some indicators, by using the drop-down menu for "Select age cohort to display".

2. If you want to see only part of the projection (for example, results beginning only in the first year of intervention coverage), you can change the first year or final year through the "First Year" and "Final Year" drop down boxes.

3. To copy the charts you may press "Print Screen" on your keyboard, and then "Ctrl and V" to paste into Paint, Word, or Powerpoint. To export data from a screen, mouse over the top left corner of any table, right click to copy all, and then press "Ctrl and V" to paste into Excel.

Graphs and bar charts

OneHealth will display a variety of graphs and bar charts, including:
- Line charts

- Two- and three-dimensional bar charts (column charts)

- Two- and three-dimensional horizontal bar charts

- Two- and three-dimensional overlap bar charts (bars for multiple projections are shown on top of each other)

- Three-dimensional perspective bar charts

Tables

OneHealth will also display data in the form of tables. In tables, each projection that is in use will be displayed in a separate column. You can scroll through the table to see all the years using the PgUp and PgDn keys or the mouse.

To print a table, right click with the mouse and select 'Print'.

You can change the decimal precision on tables by selecting a group of cells and then clicking the right mouse button and selecting 'Increment decimals' or 'Decrement decimals'.

You can copy all the data in a table to Excel or Work by selecting 'Edit' and 'Copy All' and then moving to Excel or Word and pasting the data.

Summary tables

The final display available in several modules is a summary table showing all the indicators. You can scroll through this page to see all the output. If you have more than one projection loaded, the indicators for the second projection will immediately follow the first.

4.6   Right click on an editor or result

When you hover over an **editor** and right click, the following options appear. Only options that are available for the specific editor will be enabled.

↶	Undo	Ctrl+Z
↷	Redo	Ctrl+Y
✂	Cut	Ctrl+X
▭	Copy	Ctrl+C
▭	Paste	Ctrl+V
.00→.0	Decrement Decimal	Ctrl+L
→.0.00	Increment Decimal	Ctrl+R
▤	Copy all	Ctrl+A
	Duplicate	Ctrl+D
	Interpolate	▶
	Normalize	Ctrl+N
	Multiply	Ctrl+M
	Data Source (Row)	
	All Sources	
✔	Show Thousands Separator	
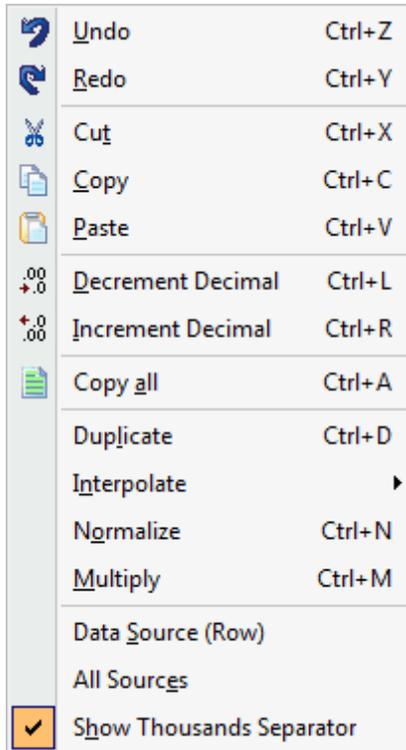
- **Copy all** can be used to copy the entire contents of an editor into Excel, including the editor name, and column and row headings.

- **Duplicate** allows you to copy information from one cell, column or row to another. To use the Duplicate function, highlight (select with the mouse) the range (column, row or cells to be affected). The first cell in the range should be the value you want to copy. Extend the range to the last year by using the mouse (hold down the left button and drag the range) or the keyboard (hold down the shift key and use the arrow keys). Then right click and select Duplicate or click on the Duplicate button (if available) to copy the value at the beginning of the range to all other cells in the range.

- **Interpolate** to enter a beginning and ending number and have the computer calculate numbers for the intervening intervals. Enter the beginning and ending values in the appropriate cells. Highlight the entire range from beginning to end. Then right click and select Interpolate or click on the Interpolate button (if available) to have the values interpolated and entered into each of the cells. When you use the right click option to interpolate values you will have the option to select the type of interpolation, including linear, s-shaped, exponential and front loaded. When you use the Duplicate button, the interpolation is linear.

- **Multiply** to multiply a cell, column or row by a specific number. Highlight the range (column, row or cells to e affected). Enter the multiplier in the dialogue box, then click "Ok" to accept. The entire range will be multiplied by the designated number.

- **Source** allows you to keep a record of the data sources and assumptions as you make the projections and will be maintained with the data files. You will also see source information for default data when it is available. It is strongly recommended that you use the source feature whenever possible to avoid later confusion. Some editors have access to the sources via the right click. Most editors have a [Source button](#) located on the bottom of the editor window.

Some editors have the Duplicate, Interpolate and Multiply options available as buttons on the bottom of the editor.

When you hover over a **result** and right click, the following options appear.

| Line 2d |
| Bar 2d |
| Bar 3d |
| Horizontal bar 2d |
| Horizontal bar 3d |
| Table plus chart |
| Copy Chart(Image) |
| Print |
| Add to favorites |
| Float display |
| Ungroup |
| Zoom In |
| Close |
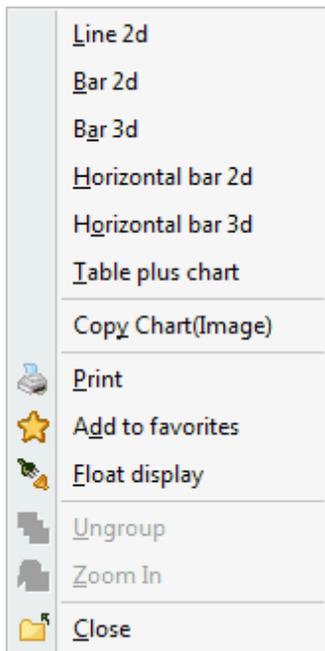
You can easily change the type of display by selecting one of the available options. You can use Copy Chart to copy the graph and paste it into another program such as Excel or Word.

5 Interacting with Excel

5.1 Copy and paste selected cells from Excel

You can copy selected cells in Excel and paste them into an editor by following these steps:

1. Enter data into Excel.
2. Select the cells that contain the data.
3. Copy the selected cells.
4. Right-click on the editor and select "Paste".

5.2 Copy and paste a table into Excel

You can copy an entire editor and paste it into Excel by following these steps:

1. Right-click on the table and choose "Copy all".
2. Paste the table into Excel.
3. This is the only way to include the column and row headers.

You can copy a portion of an editor and paste it into Excel by following these steps:

1. Click on any part of the editor and drag the mouse to highlight a portion of it.
2. Right-click and choose "Copy".
3. Paste the highlighted data into Excel.

6 OneHealth Tool
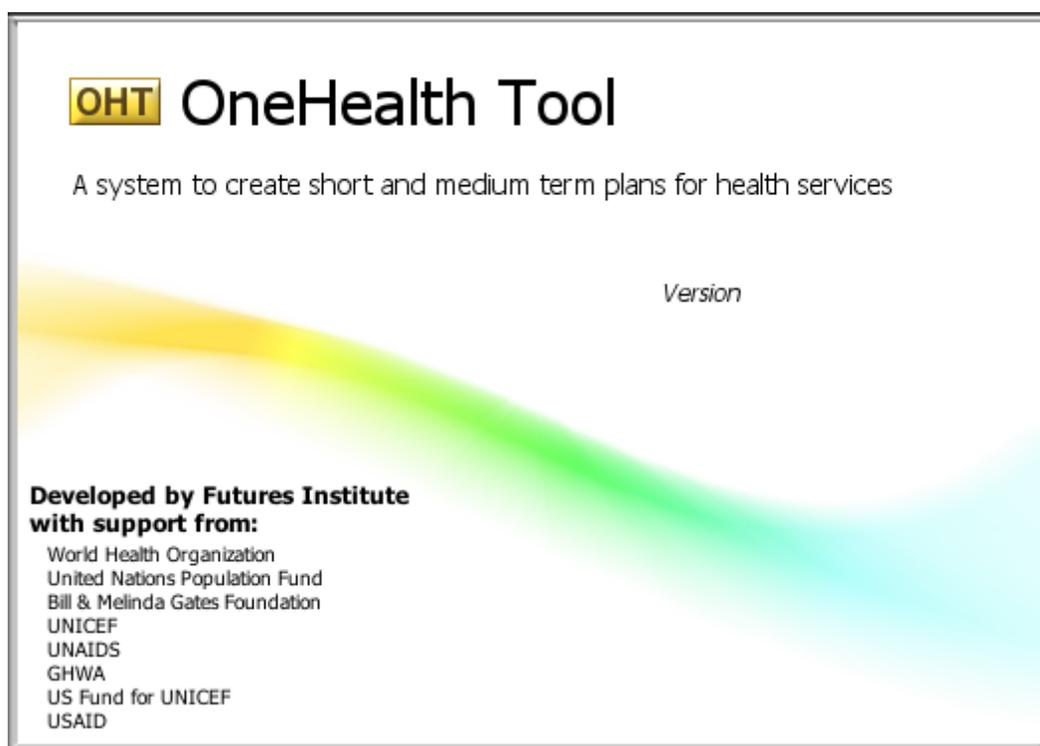
6.1 OneHealth Configuration

6.1.1 Configuration editor: General tab

Currency and exchange rate

OneHealth allows for the calculation of costs and budgeting in either US dollars or a currency of the user's choice. The user must supply exchange rates relative to the US$. The user can display results in either US$ or the chosen currency.

6.1.2 Configuration editor: Module-specific tab

Human Resources

Projections of human resources may be made based upon targets that can be set or they may be based upon policy decisions that will determine the projected human resources. In both cases, you must complete a target setting exercise.

If you choose the policy decision option, OneHealth includes a policy editor that helps you make policy decisions. The policy editor includes interactive graphs showing how close the policy decisions bring you to meeting goals or targets. If you choose the policy option and you do not complete the policy editor, unusual results will result.

If you choose the target setting option, the targets you set in the target setting editors will be those used to cost the health plan.

The decision you make here may be reversed at any time, either in the Human Resources module or in the OneHealth Configuration screen.

Logistics

Projections of Logistics needs may be calculated based on a flexible costing template or via an optimizer.

It is strongly recommended that you use the costing templates.

The use of the optimizer is appropriate only for experts in logistics planning. Many defaults must be checked and adjusted for the optimizer to be used correctly. Among these parameters are the weight and volume of commodities and geo-locations of warehouses and system endpoints. Although defaults are sometimes provided, OneHealth developers do not certify the accuracy of these defaults.

The decision you make here may be reversed at any time, either in the Logistics module or in the OneHealth Configuration screen.

6.1.3   Staff matching

Why is this important?

In the intervention costing feature of OneHealth, unit staff times are based on default staff types. The mapping in this feature will allow a linking of the default staff types in intervention costing with the custom staff types you may have entered. This mapping will then allow for a comparison of staff time needed to deliver essential services with the staff time available.

6.1.4   Facility matching

Why is this important?

The first column of the mapping will inform OneHealth of the default equipment that should be associated with this facility type. The second column of the mapping will allow OneHealth to attribute costs associated with these facilities to default levels of the health system (Community, Outreach, Clinic, or Hospital). The third column of the mapping indicates whether the facility will offer medical services or will be restricted to non-medical support functions.

6.1.5   Timeframe

OneHealth allows considerable flexibility in setting the years for a projection.

In the timeframe for costing, the first year is the baseline from which the costing will begin. This year is usually the current year. The final year is the last year for which the costing of the entire plan will be done. The first year for health system analysis is the same as the first year of the costing timeframe. The final year for health system analysis may be set for a longer time horizon. Frequently, health systems planning needs a timeframe that may be decades long to analyze the long term impacts of workforce aging, facility rehabilitation, and capital investments among other things.

Once the projection has been created, these years may be changed in the Projection Manager. However, all data for years outside of the initial range of years above will be set to zero. For example, suppose you have an editor within a health system module spanning from 2011 to 2015 in which 100 was entered for all years. If you change the final year for health systems to 2020, then data for years 2016 to 2020

will be set to zero and will have to be entered manually. Therefore, it is advised that you choose the longest time period that you might envision in your plan.

It is important to remember that the years in the Impact modules (LiST, AIM, Goals, TB, FamPlan, and DemProj) may be different from the timeframe used for costing in OneHealth. These tools often involve epidemic modeling that requires looking at historical data for proper parameterization of disease patterns. The user is invited to visit these models for more information.

6.1.6   Assignment of interventions to delivery channel packages (Delivery Channel Mode only)

Every intervention can be assigned to *at most one* package within a delivery channel. This assignment is used to define the range of interventions that is included in a package. Among other things, this assignment is used in the calculation of frontier coverages based on the bottleneck analysis. Note that some interventions are not offered at some delivery channels. For example, Management of eclampsia is not offered at the community level.

6.1.7   Custom interventions

Custom interventions will appear in the following areas of OneHealth:

- Intervention coverages

- Population in need

- Treatment inputs

- Delivery channels

To appropriately cost a new intervention, each of these areas must be visited and completed with relevant information.

IMPORTANT: The population receiving the intervention is assumed to be the entire population of your country. The **population in need** must adjust this to the appropriate population for an intervention. For example, if you have added a childhood immunization, you must adjust the "population in need" to include only children at the age when they receive the immunization. In this case, an appropriate proxy to use might be the number of births divided by the total population in a given year.

6.2   Programme or Channel Anaylsis

6.2.1   Edit staff types

Differentiating between urban and rural health plans

OneHealth does not specifically allow for differentiation of urban and rural health plans except via creation of differentiated scenarios (see user manual). On the other hand, a simple way of moving forward is to define staff types by where they will be located. For example, you may include both "Rural midwives" and "Urban midwives" among the staff types. If this is combined with facility types that are differentiated by their location, detailed planning on urban and rural lines can be accomplished.

6.2.2   Target populations

The option of changing an intervention's target population is given for the following reasons:

- To allow the user to adjust target populations for custom interventions they may have added.

- To allow for variation in the population that different countries target with specific services.
- To allow for adjustment of the target population in cases where the populations drawn from impact modules (e.g., AIM, Goals, LiST, or FamPlan) are not matching expected numbers based on country data.

If you are changing an intervention's target population, remember to do the following:

1. Designate the proportion of this new target population that will need the service in the population in need editor.
2. Identify the coverage, or actual reach, of the service in the coverage editor.

Changing the target population may result in inconsistencies between cost and impact results, as the impact modules will continue to assume the original target population. In general, we do not recommend that the user change the target populations of default interventions except in extreme cases where the user cannot make adjustments to the impact modules to match expectations. An example where serious differences would occur is the following. If the user changes the target population for ART services from people eligible for ART to total population, then the costing calculations will be made on the basis of total population while AIM continues to use people eligible for ART to calculate impact.

Click here to learn more about the Intervention costing process.

6.2.3   Intervention costing process

The determinants for intervention costs are the **number of people** receiving the intervention and the **quantity of resources** required to deliver the intervention per person.

In order to calculate the number of people receiving the services, OneHealth includes data entry fields for the following:
- Population
- Target population
- Population in need
- Coverage

All four of the above must have data entered into them in order for the tool to be able to estimate the number of people receiving the intervention by year.

Population: The overall demographic parameters for the population are entered into the DemProj module. There are country-specific defaults here.

Target population: This is where the sub-population that will receive the intervention is identified. There are global defaults available here for each intervention.

Examples of target population include:
- Pregnant women
- Adolescents
- Children aged < 1 month
- Children aged 0-59 months
- Children aged 1-59 months
- Total population
- Etc.

The user can select from a drop-down list of default populations or specify the target population of each intervention as shown below:
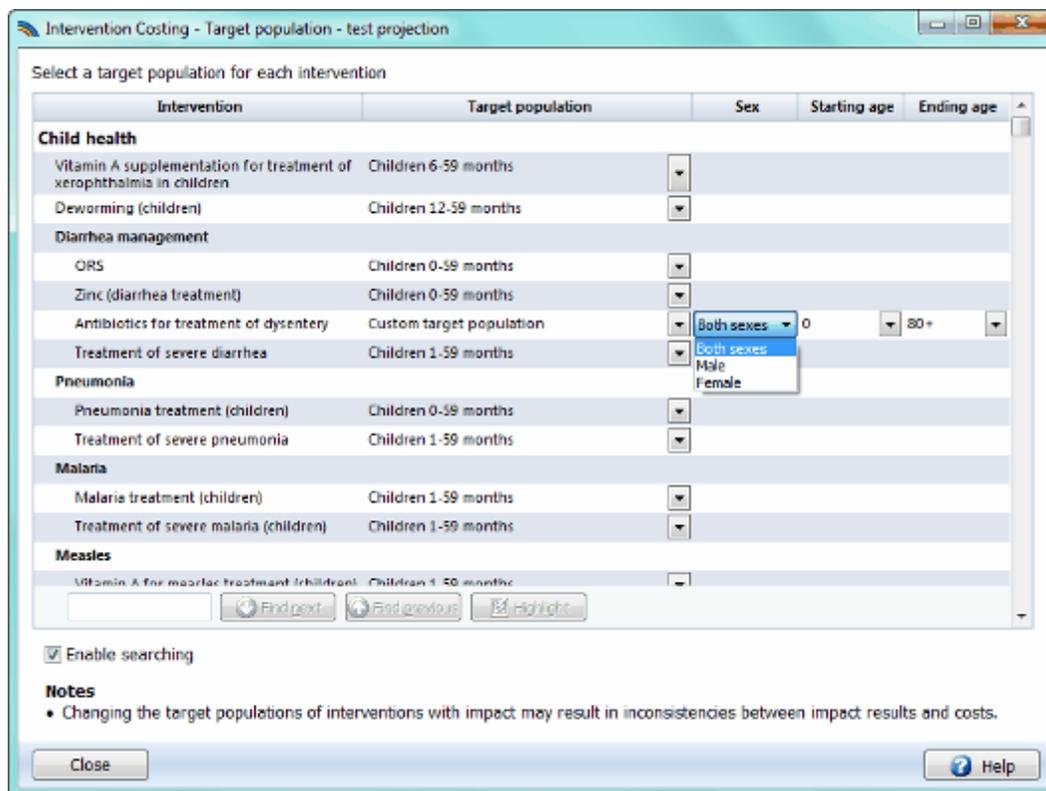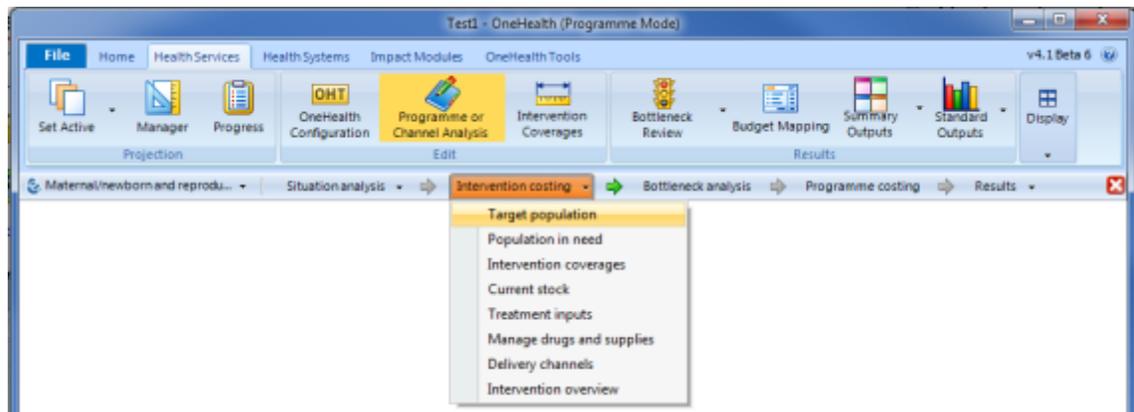
The custom target population is useful in particular for custom interventions which the user has added to the tool, which were not part of the default list of OneHealth interventions.

Population in need: This section is used to identify what share of the target population requires the intervention, per year. For most preventive care interventions, the share will be 100%. For example, antenatal care will be required for all pregnant women.

Population in need is determined by incidence and prevalence of conditions, and treatment guidelines.

In some instances, the population in need may be > 100%. For example, consider management of diarrhea with ORS. The target population is children aged 0-59 months. If we put 100% population in need, this means that each child will on average receive the intervention once per year. However, in

many settings, the incidence of diarrhea may be greater than 1.0. For example, if the incidence of diarrhea in children is estimated at 3.5 episodes per year, the population in need will then be 350%. If 1 % of all diarrhea cases are estimated to be severe, then the population in need for treatment of severe diarrhea is 3.5% (calculated as 350% x 1%).

For another example, take treatment of malaria in pregnant women. Here the target population is pregnant women, and the population in need is the percentage of pregnant women who will need treatment of malaria, per year.

Coverage: The coverage measure refers to how many people, out of the population in need, are actually receiving the intervention. This is an indicator commonly measured in household surveys such as Demographic and Health Surveys (DHS) and Multiple Indicator Cluster Surveys (MICS). E.g., among children with a fever during the past two weeks, how many were taken to a health provider for treatment?

There are three columns in the coverage editor (though the columns can be expanded to include coverage targets for all years).

- *Baseline coverage* – This is the starting coverage in the base year. Default values appearing here come from the impact modules. If the default value is zero, there may not be any data available as default for the specific intervention. Values entered into this column will drive the calculated estimates.
- *Target coverage used to assess impact and intervention costs* – This is the final target coverage for the end year of your projection. Values entered into this column will drive the calculated estimates for the end year.
- *Frontier coverage from Bottleneck analysis* – Values appearing in this column are those derived from the Bottleneck analysis for selected interventions. Values in this column do not drive any calculations in the tool – they are only available as a reference point. If users have not done a bottleneck analysis, the value showing here will by default be the same as the baseline coverage. If the user has chosen to do a bottleneck analysis, then most likely a target will show that is the suggested value that the user may consider to put as the coverage target for the final year of the projection.

In the example below, the user has not done a bottleneck analysis. Thus the values shown in the right-hand column are the same as the baseline coverage.

Notes:
- When in doubt about what value to enter for the population in need, go into the Target population editor and review what target population has been selected.
- The OneHealth Tool includes pop-up texts to guide users on default definitions for population in need, target population, and coverage. These are shown as red triangles in the upper right-hand corner of the cell. Text will appear when the user drags the cursor until it hovers above the flagged cell.

Examples for illustration:

Measles vaccine
How should data be inputted?
- The target population can be selected as births or children < 1.
- The population in need is 100%, since the recommendation is that all children are immunized.
- The current coverage may be 80-90%, depending on the country.

School health programme
A new school health programme will be set up to target children age 9-12 years in rural areas. The ambition is that 60% of schools in rural areas should be covered by 2015. How should data be inputted?

- The target population can be customized to be children from age 9 to 12. Indicate whether both sexes are covered or select males/females.
- The population in need is the percentage of children living in rural areas, who are enrolled in school. In this example, assume the proportion is 75% population in rural areas and 90% of those are enrolled in school. The population in need is then 75% x 90% = 67.5%
- The current coverage is 0%, and the target coverage for 2015 is set to 60%.

PMTCT

How should data be inputted?

- The target population should be set to "Women in need of PMTCT". This is a specific parameter that pulls the relevant data from the HIV impact module.
- The population in need here would be 100%, since the target population is already defined as Women in need of PMTCT.
- The current coverage and target coverage are country-specific.

6.2.4   Drugs and supplies editor

Interpreting this editor

This editor requires judgment and interpretation by the user. In general, the editor assumes that a drug or supply can be conceptualized as follows: A percentage of patients needing a service will receive X doses of medicine to be taken Y times per day for Z days. This is translated into a cost per average case by this equation:

Cost per average case = Percent receiving x Number of units x Times per day x Days per case x Unit cost

The percent receiving is included to allow for interventions that are differentiated by characteristics of the client. For example, severity of the condition may require that moderate and severe cases are differentiated.

Judgment is sometimes required because not all medicines or treatments can be interpreted in the same way.

For example, an intrauterine device is required for one particular family planning intervention. In this case, the percent receiving would be 100% and the units per case would be "1". However, the times per day and the days per case are irrelevant. In this case, you would put "1" in for both of these items to allow the calculation to be correctly carried out.

A second example would be a long term intervention where re-supply is done on a monthly basis. In this case, the user would need to re-interpret the column headings to allow for calculation on a monthly basis.

Using this editor

Intervention Costing - Detailed treatment inputs - OHT

Malaria treatment (children), clinic level

Drugs and supplies | Medical personnel | Outpatient visits and inpatient days

Drugs and supplies

Drug/Supply	Percent receiving this aspect of the treatment	Note	Number of units	Times per day	Days per case	Units per case	Unit cost (USD) (2010)	Cost per average case (USD) (2010)
Diagnosis								
Malaria test kit (RDT)	150.0	Assumption that some tested will be negative	1.0	1	1	1	0.45	0.68
Slide and stain for microscopy	0.0		1.0	1	1	1	0.15	0.00
Treatment								
Artemether + Lumefantrine, tablets, 20 + 120 mg, 6 x 1 blister	0.0	2x a day for 3 days	1.0	2	3	6	0.14	0.00
Artesunate + Amodiaquine, tablets, 50 mg + 153 mg, 3 + 3 blister	100.0	1 tablet each 1x a day for 3 days	1.0	1	3	3	0.30	0.91
Artesunate + SP, tablets, 50 mg + 500 mg + 25 mg, 3 + 1 blister	0.0	3 tablets of Arte, 1 of SP	1.0	1	1	1	0.55	0.00
Total cost								1.58

Drugs and supplies: Add | Delete
Groups: Add | Edit | Delete

☐ No drugs or supplies are required for this intervention.

Clear treatment inputs | Copy treatment inputs | Load default treatment inputs

Close | Manage drugs and supplies | Help

Drugs and supplies (3) may be added or deleted from the various groups in this editor (1) by using the "Add" (5) and "Delete" (6) buttons, respectively. To add a new drug or supply, first click on a group heading (2) to select a group under which the drug or supply should be placed. Alternatively, you may click on a drug or supply within a group. The new drug or supply will be added to the same group as that of the selected drug or supply. Click "Add" to select a drug or supply from a list. Note that a drug or supply cannot be added to the same group more than once. However, you may add a drug or supply to different groups within the same editor. To delete a drug or supply, click on the drug or supply you would like to delete and then click 'Delete'.

Drugs and supplies may be organized into several groups by using the "Add" (7), "Edit" (8), and "Delete" (9) buttons. Click "Add" to create a new group into which drugs and supplies may be placed. To edit the name of an existing group, click on its group heading to select it and then click "Edit". To delete an existing group, click on its group heading to select it and then click "Delete". When deleting a group, you may choose to either delete all drugs and supplies within that group or move all drugs and supplies within that group to a different group.

Click "Manage drugs and supplies" (4) to bring up a list of all drugs and supplies in which you may create custom drugs and supplies, edit the names of existing drugs and supplies, and delete drugs and supplies.

6.2.5 Bottleneck analysis

Effective coverage

The baseline effective coverage is a baseline coverage item that can be edited only in the intervention coverages editor.   The effective coverage in the frontier coverage column is a calculated value that is used in the calculation of frontier coverages for interventions associated with the selected tracer.

6.2.6 In-service / refresher training editor

In the first column of numbers enter directly or follow the "double click instructions" to set a target for staff to be trained. In the second column of numbers enter the number of staff who have already been

trained. The third column of numbers will automatically calculate the staff that remain to be trained. Under the years you are able to distribute the training across the years of your plan. You will see that the fourth column changes as you add or subtract staff to be trained in any given year. When the third and fourth columns are equal you have distributed the training across the years in a manner consistent with your target.

6.2.7   Office and equipment costs editor

What are these costs?

Recurrent costs for existing employees are year to year material support required for an employee to do their job and are not entered elsewhere in the tool. Examples could be the prorated cost of facilities, materials, phone line, etc.

Cost of setting up an office for a new employee might include purchase of furniture and computer equipment.

You should exercise judgment to not include costs here that are included elsewhere in the tool. For example, if a staff member sits in a health facility where his/her office and support are provided, you would not include those costs here.

6.2.8   Delivery channels

Channels not costed by OneHealth

OneHealth is designed primarily to cost Ministry of Health activities. However, it is understood that many activities related to health are implemented outside the Ministry of Health, and these activities impact the health of a nation. Therefore, the user can distribute coverage of health interventions across health channels under the control of the Ministry of Health and under channels not under the control of the Ministry of Health. It is implicit in the labels Community, Outreach, Clinic, and Hospital that these are Ministry of Health provided or financed activities. Other activities are carried out by WASH (scroll down for more information on WASH), other government sectors, or the private sector.

The intervention costs (drugs, supplies) associated with other government sectors or the private sector are not costed in OneHealth. If the user would like for these items to be costed, their share of service delivery should be attributed to one of the government health channels (i.e., Community, Outreach, etc.). Furthermore, health personnel and facility use associated with these other sectors are not tabulated. Again, if the user would like these to be tabulated (s)he should attribute the shares of service delivery to one of the government health channels.

WASH

WASH is a very special case in OneHealth. As a delivery channel, it is assumed that its activities are implemented by a ministry other than the Ministry of Health. Interventions carried out by the WASH sector are not costed, and resource requirements are not tabulated within OneHealth. On the other hand, there are interventions categorized as WASH. These include, by default, safe water, sanitation, hand washing, excreta removal, etc. These activities can be carried out by any of the channels. For example, hand washing promotion is frequently carried out in the Community by Community Health Workers. On the other hand, improvements to water systems are carried out by the WASH delivery channel. Finally, there is a programme area called WASH. As a programme area, it has health interventions associated with it when OneHealth is running in programme area mode and programme costing elements associated with it in both programme area mode and delivery channel mode.

	WASH as a delivery channel	WASH as a collection of interventions	WASH as programme area
Included in OneHealth costs and resource requirements?	NO	YES	YES
Frequently attributed interventions	Piped water, sanitation	Hand washing, safe removal of children's stools	Programme costs incurred by the Ministry of Health for improving water and sanitation

6.3   Intervention Coverages

Choosing scale-up patterns   Scale-up of childbirth care interventions

This editor allows you to set intervention coverages for both estimating mortality impact and intervention-related costs. You may change the baseline or target coverages for any interventions. The calculated frontier coverage from Bottleneck Analysis is noted for your reference.

When you have completed your coverage scale-up plan, click the button "Transfer coverages to impact modules". Only by clicking this button will your changes to interventions with calculated impact be permanent. Coverages for interventions without calculated impact (marked in red) are saved automatically in the Intervention Coverages editor.

By default, a linear scale-up is implemented. If you would like to customize your scale-up trajectory, check off "Show all years of scale-up". You may then directly enter a scale-up or use the right-click options for automated scale-up (e.g., S-Shaped, Front Loaded, etc.). Additional information on choosing scale-up patterns can be found below.

Choosing scale-up patterns

Scale-up of interventions is phased differently depending on programme priorities and capacities for implementation. OneHealth provides four default scale-up patterns: 1) linear; 2) S-shaped; 3) exponential; and 4) front-loaded. The following is a brief description of when each might be appropriate.

1) Linear is used if it is believed that a steady amount of improvement can be achieved over the course of scale-up. An example of this might be when roll-out of a programme is done region by region over the course of the scale-up period.

2) S-shaped is considered the classic scale-up curve and probably appropriate for most cases. This is used when initial investments in time and resources are needed with a pilot group initially. In a second phase, there is rapid scale-up as easy-to-reach or easy-to-target populations receive the services. In a third phase, hard-to-reach populations must be addressed and progress slows.

3) Exponential is a rarely encountered curve for scale-up. A typical example of this scale-up is if initial work on services improvement is slow and rapid improvement occurs at the end of the scale up-period. Alternatively, one might think of this as a truncated S-Curve where hard-to-reach groups will not be addressed until a later programme period (and thus the plateau is not observed).

4) Front-loaded is used when initial investments have already been made and rapid scale-up is considered likely from the beginning of the planning period. Alternatively, this could be used in cases where large initial investments are not needed and again rapid scale-up will occur immediately.

Click here to learn more about the Intervention costing process.

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Scale-up of childbirth care interventions

OneHealth calculates the impact of childbirth care interventions with the Lives Saved Tool (LiST).

For many purposes, OneHealth will automatically transfer intervention scale-up to LiST when you click on "Transfer coverages to impact modules". It is important to note that the intervention scale-up will be done in a manner that requires the least improvements in the delivery levels (i.e., essential care, basic emergency obstetric care, and comprehensive emergency obstetric care). However, the impact of most childbirth care is linked to the birth delivery levels. For example, interventions available at the CEMOC level are more effective than those available only via essential care. An implication of this is that the calculation of the impact of many improvements in the quality of care cannot be directly reflected in the coverage editors of OneHealth.

If you would like for OneHealth outputs to reflect improvements in essential care, basic emergency obstetric care (BEMOC), or comprehensive emergency obstetric care (CEMOC), you must go to the childbirth coverage editor of the Lives Saved Tool (see screen shot below for navigation hint). If you scale up the availability of BEMOC or CEMOC, it is important that you cost the activities necessary for these improvements.

6.4   Drug and Supply Unit Costs

The prices entered in this editor should be real prices, not inflation-adjusted prices. Inflation rates for the projection period are entered in the OneHealth Configuration and are applied to all cost elements in the projection in the results. Changes in prices entered in this editor should be based on the belief that real prices will go up or down because of changes in the procurement environment, improved technology, improved negotiation power, etc.

6.5   Budget Mapping

The budgeting process   Hierarchical budgeting   Important information on mapping drugs and commodities

The budgeting process

The OneHealth budgeting process consists of the following steps:
1. The user defines a name for one or more budgets.
2. The user selects a budget to work on under the configuration.
3. The user defines budget categories either by typing them in or by uploading a list.
4. The user maps the OneHealth costing categories to the budget categories created in step three.
5. The user can view the created budget.

Hierarchical budgeting

OneHealth cannot automatically create a hierarchical budget with subtotals and totals included. On the other hand, strategic creation of budgeting categories can make the process much easier with Excel. It is recommended that you number each budget category according to its place within a budget. For example, salaries for midwives located in clinics might be numbered as follows: 3.2.14.1. Midwife salaries – clinic where 3 denotes the part of the budget where human resources are handled, 2 refers to clinics, 14 refers to midwives as the 14th human resource type, and 1 refers to salaries as opposed to benefits or incentives.

Important information on mapping drugs and commodities

Drugs and commodities in OneHealth are planned or projected in both the Logistics and Intervention costing modules of the tool. The Intervention costing module projects the needed quantities of drugs and commodities to deliver interventions scaled up in Intervention costing. The Logistics module allows the user to add drugs and commodities that are not planned via the interventions in Intervention costing. In addition, the Logistics module assists in planning for wastage and for sufficient safety stock of both the drugs and commodities needed for intervention scale-up and the additional drugs and commodities planned for in the Logistics module.

The budget mapping for the drugs and commodities planned for intervention scale-up is done within the "Intervention Costing" module of the Budget Mapping tool. You will find each of these drugs or

commodities listed once there. The budget mapping for wastage and safety stock for these drugs and commodities is done within the "Logistics" module of the Budget Mapping tool. You will see each of these drugs and commodities listed twice, once for wastage and once for safety stock. Also within the "Logistics" module of the Budget Mapping tool are three instances of the drugs and commodities added in the Logistics module of the tool: once for the drugs and commodities to deliver services, once for wastage, and once for safety stock.

We strongly recommend that you use the aggregate functions in the tools to assist you as you do the budget mapping. For example, if you are interested in mapping individual elements of the wastage for commodities and drugs, you may want to show in aggregated-fashion all other elements of the "Logistics" module of the Budget Mapping tool. In this way, you may be sure that you are mapping only the wastage elements.

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6.6 Human Resources

6.6.1 Staff baseline editor

Health system staff may be posted to facilities, district/regional administration, or central administration. Most often, the staff posted to facilities are involved in direct service delivery, although some staff will also perform management, administrative, or support functions. Staff posted to district/regional level or central usually have managerial or administrative functions. However, these staff will frequently be qualified medical personnel, especially if they perform planning or programmatic tasks.

6.6.2 Staff time utilization editor

These data input are used to make estimates of capacity utilization. The intervention costing module makes estimates of time spent on health service delivery. The programme costing module makes estimates of time that staff spend in training. These various pieces of information are combined together to provide the OneHealth user with a staff capacity utilization estimate in the summary outputs. This input is not necessary for OneHealth to make costing or impact estimates.

6.6.3 Retention incentives

Retention incentives will have both a cost and an anticipated impact on the attrition rate. The cost of incentives will be calculated based on the inputs the user provides. If you choose to compute Human Resources results based on targeted values, then the impact of reduced attrition rate will impact the number of staff that need to be hired. However, it will not impact the number of staff available. If you choose to compute Human Resources based on the Policy analysis, then the impact of reduced attrition rate will impact the number of staff that need to be hired and, in conjunction with recruitment, will determine the number of staff available.

Types of retention incentives

Retention incentives are provided to employees to reduce the probability that they will leave employment within the health sector or leave their assigned post. Examples of incentives are subsidized transportation, additional vacation, subsidized housing, etc. If all employees currently receive a particular incentive, the user may consider including the incentive as part of either salaries or benefits since its provision will not decrease current levels of attrition.

Impact of retention incentives

The impact of incentives is expressed as a percent reduction in a particular cause of attrition. For example, suppose the attrition due to a given cause is 25 percent. If the impact of a housing subsidy were a 50 percent reduction in attrition, then the post-incentive attrition would be 12.5 percent (i.e., 25% - 50% x 25% = 25% - 12.5% = 12.5%).

The evidence base on the impact of HR incentives is weak. The user is encouraged to use their best judgment on the potential impact of incentives and to do sensitivity testing.

6.6.4 Target setting configuration editor

Human resources may be targeted in several fashions, depending on if they are posted to facilities, district/regional administration, or national administration. Most frequently, staff at facilities are targeted based on facility norms. An exception to this rule may be community health workers who may be targeted based on population. At the regional and central level, staff are more frequently targeted based on population or with direct entry to fill specific positions.

6.6.5 In-service training editor

In-service training costs are generic training that is provided to health personnel. It may be that such things are refresher courses on civil service rules or benefits or general training on human resources procedures.

6.6.6 Attrition baseline

Retention incentives will have both a cost and an anticipated impact on the attrition rate. The cost of incentives will be calculated based on the inputs the user provides. If you choose to compute Human Resources results based on targeted values, then the impact of reduced attrition rate will impact the number of staff that need to be hired. However, it will not impact the number of staff available. If you choose to compute Human Resources based on the Policy analysis, then the impact of reduced attrition rate will impact the number of staff that need to be hired and, in conjunction with recruitment, will determine the number of staff available.

6.7 Infrastructure

6.7.1 Medical equipment

Health Posts

- This equipment is for a basic day clinic serving a population of 1,000 people

- At the end of this list is equipment for a TB microscopy lab serving a population of approximately 100,000.

Health Centers

- This list is for a facility serving a population of about 10,000 people. It has from 2 to 5 beds; in some cases the number of beds could raise up to 20

- At the end of this list is equipment for a TB microscopy lab serving a population of approximately 100,000.

District Hospitals

- This equipment list is for a facility that serves a population of about 100,000 people. It would have a minimum of 100 beds.

- At the end of this list is equipment for a TB microscopy lab serving a population of approximately 100,000 and equipment for a TB molecular lab performing approximately 1,000 line-probe assays.

Provincial Hospitals

- This equipment list was developed for a facility that provides service to a population of minimum 1,000,000 people. It has at least 300 beds and supports several clinical specialties.

- At the end of this list is equipment for a TB microscopy lab serving a population of approximately 100,000; equipment for a TB molecular lab performing approximately 1,000 line-probe assays; a culture laboratory performing approximately 12,000 cultures; a DST laboratory performing approximately 1,000 first-line DST (and possibly 100 second-line DST); and optional additional equipment for culture and DST laboratories.

Central Hospitals

- This equipment list was developed for a specialized hospital providing service to a population of at least 1,000,000 people. It has a minimum of 200 beds. All the specialties are provided in this hospital.

- At the end of this list is equipment for a TB microscopy lab serving a population of approximately 100,000; equipment for a TB molecular lab performing approximately 1,000 line-probe assays; a culture laboratory performing approximately 12,000 cultures; a DST laboratory performing approximately 1,000 first-line DST (and possibly 100 second-line DST); and optional additional equipment for culture and DST laboratories.

6.8   Financial Space

6.8.1   General Government Health Expenditure approaches

Manual approach: You can choose year-on-year growth rates or a fixed annual growth rate for the projection period. This should be done for both domestically and externally financed GGHE.

Coefficient approach: The first coefficient will describe the relationship between the growth of GDP and the growth of Domestic General Government Health Expenditure. When the coefficient is greater than 1.00, the growth of Domestic General Government Health Expenditure is greater than the growth of GDP. When the coefficient is less than 1.00, the growth of Domestic General Government Health Expenditure is less than the growth of GDP. The second coefficient describes the fraction of the increase in external resources that is devoted to Domestic General Government Health Expenditure. Note that this increase includes external resources that were originally intended for use by the government and those that were originally intended to go through other expenditure channels.

Target approach (as % of GGE): Set target value for GGHE (total) as a % of general government expenditure. Then enter arrival year, i.e. when the target will be met, and years of delay before the base year value starts to move toward the target.

Target approach (in constant prices): Set target value for GGHE (total) in constant prices. Then enter arrival year and years of delay.

6.8.2   Private Health Expenditure options

There are two options for entering private health expenditures.

"Growth as coefficient's option" is UNCHECKED: Manual input. Enter either year-on-year growth rates or a fixed annual growth rate for the projection for each of the disaggregated private health expenditure variables.

"Growth as coefficient's option" is CHECKED: Set coefficients to reflect the relationship between private health expenditure (total) and i. GDP; ii. GGHE (net of % change in GDP).

7   Spectrum Modules

7.1   DemProj
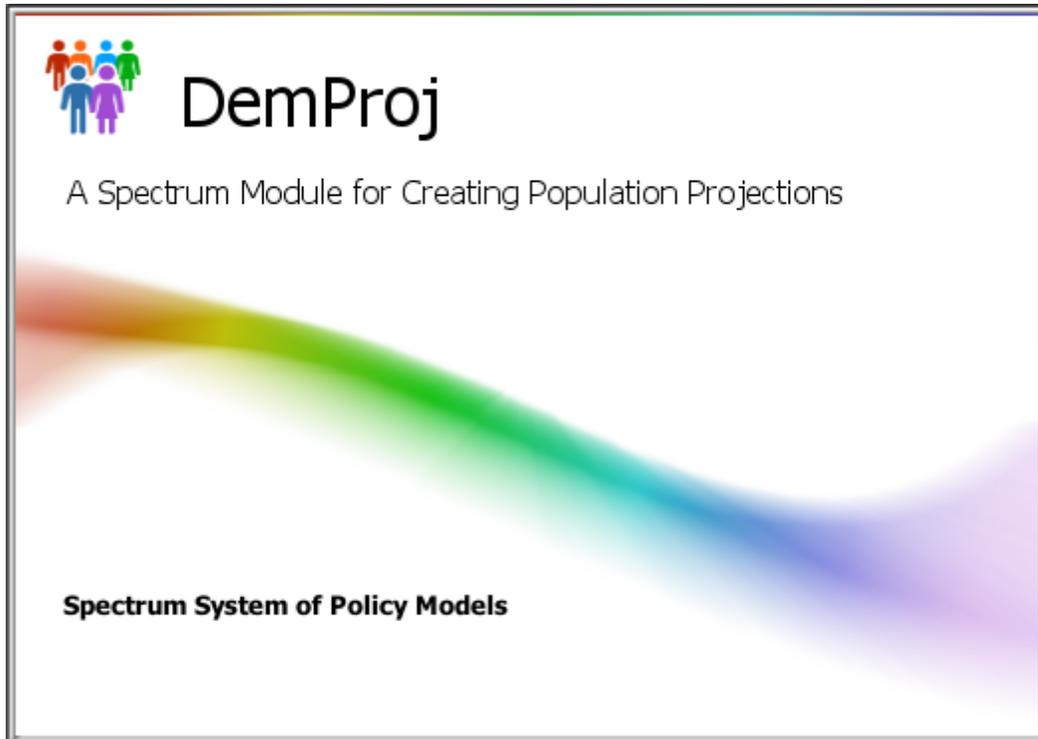
7.1.1   What is DemProj?

The demographic model in Spectrum, known as DemProj, is a computer program for making population projections for countries or regions. The program requires information on the number of people by age and sex in the base year, as well as current year data and future assumptions about the total fertility rate (TFR), the age distribution of fertility, life expectancy at birth by sex, the most appropriate model life table, and the magnitude and pattern of international migration. This information is used to project the size of the future population by age and sex for as many as 150 years into the future. If desired, the projection can also estimate the size of the urban and rural populations. Linking DemProj with other modules in Spectrum makes it possible to examine the demographic impact of AIDS (AIM), the family planning service requirements to achieve demographic and health goals (FamPlan), the costs and benefits of family planning programs and the socioeconomic impacts of high fertility and rapid population growth (RAPID).

DemProj was first produced in 1980. Since then, it has been used by a large number of planners and researchers around the world. It has been updated from time to time in response to comments and suggestions from users. This current release incorporates a number of new features in response to these comments.

DemProj (and the entire Spectrum system) is designed to produce information useful for policy formulation and dialogue within a framework of easy-to-use computer programs. The focus is on the generation of information useful for policy and planning purposes rather than detailed research into the underlying processes involved. For this reason, the programs are designed to be used by program

planners and policy analysts. DemProj uses data that are readily available and requires little demographic experience beyond the information available in this manual.

7.1.2   Why make population projections?

Population projections are useful for a variety of purposes, most commonly as a basis for planning. For example, assessing a nation's or region's needs for new jobs, teachers, schools, doctors, nurses, urban housing, or food requires knowledge of the number of people who will be requiring services. Thus, population projections serve as the starting point for most projections of future need.

Population projections are also important for policy dialogue. A key aspect of the policy process is recognizing that a problem exists and placing that problem on the policy agenda. Since rapid population growth contributes to many of the major development problems, population projections are required to illustrate the future magnitude of the problems. For example, a population projection is required in order to illustrate the future threat to forests from excessive use of fuel wood.

Population projections are required also in areas of the policy process that involve proposals to solve problems. In this case, population projections are required to show the magnitude of the services that will be required for the proposed solution and the improvements in population-based indicators that will occur. For example, a discussion of the need for and impact of an expanded program of immunization requires a population projection to show the number of children who will need vaccination in the future and the reduction in morbidity and mortality rates that could be achieved by the proposed program.

Looking at future population composition and size usually requires producing several projections, for two reasons. First, projections are based on assumptions about future levels of fertility, mortality and migration. Since these are simply assumptions, it is often wise to consider low, medium and high variants of each assumption so that the range of plausible projections can be determined. Second, when population projections are used for policy dialogue, it is usually important to show how various rates of population growth would affect the projections. For example, an analysis of the impacts of population growth on education typically would include a high-growth projection to show the magnitude of the problem under current conditions, and a low-growth projection to show how a slower-growing population would put less pressure on the education system to meet national education goals.

7.1.3   Steps in making a population projection

There are seven key steps in making most population projections. The amount of time spent on each step may vary, depending on the application, but most projection activities will include at least these seven steps.

1. **Select geographic area.** Population projections are normally made at the national level. However, projections may also be made for other geographic areas, such as urban areas, capital cities, provinces, districts, and catchment areas. For example, the trend toward decentralization of public programs in many countries has greatly increased the need for projections at the district and provincial levels. The first step in making a population projection is to decide the most appropriate geographic area for the application.

2. **Determine the period of the projection.** Population projections start at some base year and continue for a certain number of years into the future. The base year is often selected on the basis of data availability and is usually the year of the most recent census or large-scale survey. The number of years to project is determined by the use of the projection. Planning activities generally focus on short-term projections (five years), while projections used for policy dialogue often use a longer time horizon (10-30 years).

3. **Collect data.** At a minimum, base year data need to be collected for the number of people by age and sex, the TFR, and life expectancy at birth. Since the population projection will only be as good as the data on which it is based, it is worth the effort to ensure that appropriate and high-quality data are collected and prepared before starting the projection.

4. **Make assumptions.** Population projections require assumptions about the future levels of the total fertility rate (TFR), life expectancy at birth, and international migration. Assumptions regarding the most appropriate model tables (see Sections III B and III C) for fertility and mortality are also required. These assumptions should be carefully considered and based on reasonable selection guidelines.

5. **Enter data.** Once the base year data are collected and decisions are made about projection assumptions, DemProj can be used to enter the data and make a population projection.

6. **Examine projections.** Once you make a projection, it should be examined carefully. This scrutiny includes consideration of the various demographic indicators produced, as well as the age and sex distribution of the projection. Careful examination of these indicators can act as a check to ensure that the base data and assumptions were understood and were entered correctly into the computer program. This careful examination is also required to ensure that the consequences of the assumptions are fully understood.

7. **Make alternative projections.** Many applications require alternative population projections. Once the base projection has been made, the program can be used to generate alternative projections quickly by varying one or more of the projection assumptions.

7.1.4   Before you get started

You will need to collect data and make certain decisions before running the model. For example, to set the projection parameters, you will need to decide

- The first year of the projection (usually the latest year for which you have population data)
- The last year of the projection
- Whether you want to project the total population or whether you want to break it down into urban and rural segments
- Whether you want to enter population numbers in terms of thousands or millions

The data you will need include (click the link to see more detailed information):

- The first year population, broken down by sex, and in age categories of 0-4, 5-9, etc. until the final category of 80+
- Total fertility rate (TFR)
- Age-specific fertility rates (ASFR)
- Sex ratio at birth (the number of male births per 100 female births); default is 105
- Life expectancy for the first year, male and female
- The model life table you want to use
- International migration: Net migrants per year by sex and age

- [Regional assumptions](): Sex and age information in rural and urban categories for the first year, if you want to break the projections down into rural and urban populations

7.1.5   Demographic input editors

This section covers the DemProj inputs in the order that the model needs them:

- Base year population by age and sex
- Fertility
- Mortality
- International migration

Overall, these inputs fit into one of the three population processes: fertility, mortality, and migration. A population projection accommodates these processes by using information on the overall level of each process, and its shape - or age pattern. For the sake of efficiency - and quite often for accuracy - the shapes (age patterns) of the three components are supplied by model schedules.

Demographic research has long observed and collected patterns of data. Model schedules attempt to capture these patterns with as few parameters as warranted. Such model schedules are then used to evaluate the quality of other demographic data; to smooth schedules of fertility, nuptiality, migration, or mortality; to provide building blocks in estimating levels and trends of demographic processes; and to forecast the behaviors of these processes in a population. In this last application, DemProj uses model patterns for two processes, fertility and mortality:

Fertility
1. TFR
2. Age distribution of fertility

Mortality
1. Life expectancy at birth
2. Age-specific mortality

7.1.5.1   Projection parameters

Using the editor

When you click on "Projection parameters" the following screen appears:

You will notice that there is only one screen for projection parameters and it is not set up as a typical editor because it is not necessary here to enter or review data.

First year, Final year and Projection period
These entries cannot be changed here; they are shown for information only. Users can change these parameters by visiting the Projection Manager.

Currency name
This is the name used to label the currency units.

Enter first year ages by single age
This box is checked by default so that the population displayed in the First year population editor is by single age. Uncheck the box if you would like to see the population displayed in five year age groups.

COVID-19 deaths
Check this box if you want to enter excess deaths due to COVID-19. Note that if you are using demographic data from World Population Prospects 2022 you do not want to do this since COVID-19 deaths are already included in those estimates.

Custom population
The 'Custom population' option indicates that Spectrum should adjust its population projection to match data that you enter. This is necessary in cases when a projection made using the official trends in TFR, life expectancy and migration does not exactly match the official population estimates or projections. To use this feature you need to prepare a CSV file that has the population by age and sex for each year of your projection. When Spectrum projects the population it will check this file at the end of each year and make small adjustments to the population to match the data in the CSV file. This can be thought of as adjusting migration in order to match the population estimates.

The file should be formatted as follows:

First row: First column is blank, the remaining columns have the years of the projection from the first to the last

Second row: The first column should have 'Males'. All other columns are blank

Row 3 to 83: The first column has the single age. The remaining columns have the population for males of that age in the corresponding year.

Row 84: The first column has 'Total'. The remaining columns have the total population for each year.

Row 85: The first column has 'Females'. The remaining columns are blank.

Rows 86 to 166. The first column has the single age. The remaining columns have the population for females of that age in the corresponding year.

Row 167: The first column has 'Total'. The remaining columns have the total population for each year.

The file should be created in Excel and saved as a CSV file.
A section of the file is shown below:

	A	B	C	D	E	F	G	H
1		1981	1982	1983	1984	1985	1986	1987
2	Males							
3	0	766,577	786,975	807,915	829,412	851,482	874,139	897,398
4	1	791,409	811,910	832,942	854,518	876,654	899,362	922,660
5	2	804,663	825,157	846,172	867,723	889,822	912,484	935,724
6	3	808,526	828,915	849,818	871,248	893,218	915,743	938,835
7	4	805,184	825,383	846,088	867,312	889,069	911,371	934,233
8	5	796,923	816,856	837,288	858,231	879,697	901,701	924,254
9	6	785,930	805,533	825,626	846,220	867,327	888,961	911,135
10	7	774,095	793,315	813,013	833,199	853,887	875,089	896,816
11	8	762,818	781,610	800,866	820,595	840,811	861,525	882,749
12	9	752,023	770,350	789,124	808,355	828,055	848,235	868,907
13	10	740,058	757,888	776,147	794,847	813,997	833,608	853,692
14	11	723,893	741,198	758,918	777,060	795,637	814,657	834,133
15	12	699,909	716,667	733,825	751,395	769,385	787,807	806,669
16	13	666,159	682,351	698,936	715,925	733,326	751,150	769,408

7.1.5.2   Demographic data

7.1.5.2.1 First year population

Using the editor

The population by age and sex in the base year is entered in this editor. It is displayed by single year by default. If you prefer to see the data displayed in five year age groups then you should uncheck "Enter first year ages by single age" in the Projection parameters editor. Unless you opted to not select a country, you will see default country specific values. Click the "Source button" to see the source for the data. You can modify these default values by following these steps:

1. Enter the size of the population by age and sex in the appropriate cells in the editor. The total number of males and females will be automatically calculated and displayed in the last row of each column.

2. If your projection includes an urban and rural projection, enter the urban population size by age and sex. If you are not including urban and rural projections, these columns will not be displayed.

3. Check to be sure that the total male and female populations are correct once you have entered all the required information. If they are not, you have probably entered a number incorrectly in one or more of the cells.

What is the first year population?

All population projections must start somewhere. The starting point is the number of people in the population by age and sex in the base year. For both males and females, the population is divided into five-year age groups from 0-4 to 75-79. There is also a final age group for those people aged 80 and older.

If you change the first year population, Spectrum will determine the percent change and apply this percent to the DemProj population and migration. Spectrum will then recalculate the projection starting at 1970 in order to recreate the epidemic based on your population changes.

World Population Prospects 2019

Data from the United Nations Population Division's World Population Prospects 2019 Revision are built-in to Spectrum and will be loaded by default when you start a new projection and select a country. You can replace these data with your own data if you prefer. Other sources of data are described below.

National census reports

Base year population figures are available from a number of sources. Usually, the best source will be a national census. Census reports always include tables showing the size of the population by age and sex. Often these tables are available for the national level and for provincial or district levels.

Issues with raw census data

Several types of problems can exist in raw census figures, including under-reporting, age misreporting, and undefined ages. Census tables should be adjusted to minimize these problems. Underreporting can occur for a variety of reasons. For example, occasionally certain geographic areas or social status groups are entirely or partially missed in the census. Sometimes respondents intentionally misreport in order to avoid identifying military age males, marriageable age females, or family members that may affect the family's taxes. Age misreporting can occur when ages are purposely or unintentionally reported incorrectly, such as when ages are rounded to the nearest five-year age group or when ages are unknown. In most censuses, there will also be a certain proportion of the population with age undefined. These problems should be corrected through standard demographic procedures and reported in later census reports, but in many developing countries these reports may not be done or may only appear many years after the census is completed. Therefore, it is important to be sure that corrected census figures are used whenever possible, rather than raw census tables.

Additional data sources

There are other sources of population data if recent census reports are not available. The Population Division of the United Nations publishes a considerable amount of population data. The most useful sources for population projections are the Demographic Yearbook, which contains the most recent census data for most countries; and the World Population Prospects, published every two years and containing population estimates and projections for most countries of the world. The latest edition of World Population Prospects may be a particularly useful source if country data are unavailable, since it will contain estimates of base year populations as well as assumptions about future levels of fertility, mortality and migration. World Population Prospects contains estimates and projections of population by five-year age groups that have been adjusted for misreporting. These data may be used when reliable census data are not available. Spectrum contains country specific data from World Population Prospects that can be used to prepare projections.

The U.S. Census Bureau also publishes a set of population projections for the countries of the world called World Population Profile. Other sources, such as the Population Reference Bureau's World Population Data Sheet or the World Bank's World Development Indicators, list the total population of most countries of the world but do not provide age and sex specific numbers.

Population estimates may also be accessed from various Internet sites, including:
- United Nations population projections
- U.S.Census Bureau
- Population Reference Bureau

7.1.5.2.2 First year population (2)

Using the editor

The population by age and sex in the base year is entered in this editor. It is displayed by single year by default. If you prefer to see the data displayed in five year age groups then you should uncheck "Enter first year ages by single age" in the [Projection parameters](#) editor. Unless you opted to not select a country, you will see default country specific values. Click the "Source button" to see the source for the data. You can modify these default values by following these steps:

1. Enter the size of the population by age and sex in the appropriate cells in the editor. The total number of males and females will be automatically calculated and displayed in the last row of each column.

2. If your projection includes an urban and rural projection, enter the urban population size by age and sex. If you are not including urban and rural projections, these columns will not be displayed.

3. Check to be sure that the total male and female populations are correct once you have entered all the required information. If they are not, you have probably entered a number incorrectly in one or more of the cells.

What is the first year population?

All population projections must start somewhere. The starting point is the number of people in the population by age and sex in the base year. For both males and females, the population is divided into five-year age groups from 0-4 to 75-79. There is also a final age group for those people aged 80 and older.

If you change the first year population, Spectrum will determine the percent change and apply this percent to the DemProj population and migration. Spectrum will then recalculate the projection starting at 1970 in order to recreate the epidemic based on your population changes.

World Population Prospects 2019

Data from the United Nations Population Division's World Population Prospects 2019 Revision are built-in to Spectrum and will be loaded by default when you start a new projection and select a country. You can replace these data with your own data if you prefer. Other sources of data are described below.

National census reports

Base year population figures are available from a number of sources. Usually, the best source will be a national census. Census reports always include tables showing the size of the population by age and sex. Often these tables are available for the national level and for provincial or district levels.

Issues with raw census data

Several types of problems can exist in raw census figures, including under-reporting, age misreporting, and undefined ages. Census tables should be adjusted to minimize these problems. Underreporting can occur for a variety of reasons. For example, occasionally certain geographic areas or social status groups are entirely or partially missed in the census. Sometimes respondents intentionally misreport in order to avoid identifying military age males, marriageable age females, or family members that may affect the family's taxes. Age misreporting can occur when ages are purposely or unintentionally reported incorrectly, such as when ages are rounded to the nearest five-year age group or when ages are unknown. In most censuses, there will also be a certain proportion of the population with age undefined. These problems should be corrected through standard demographic procedures and reported in later census reports, but in many developing countries these reports may not be done or may only appear many years after the census is completed. Therefore, it is important to be sure that corrected census figures are used whenever possible, rather than raw census tables.

Additional data sources

There are other sources of population data if recent census reports are not available. The Population Division of the United Nations publishes a considerable amount of population data. The most useful sources for population projections are the Demographic Yearbook, which contains the most recent census data for most countries; and the World Population Prospects, published every two years and containing population estimates and projections for most countries of the world. The latest edition of World Population Prospects may be a particularly useful source if country data are unavailable, since it will contain estimates of base year populations as well as assumptions about future levels of fertility, mortality and migration. World Population Prospects contains estimates and projections of population by five-year age groups that have been adjusted for misreporting. These data may be used when reliable census data are not available. Spectrum contains country specific data from World Population Prospects that can be used to prepare projections.

The U.S. Census Bureau also publishes a set of population projections for the countries of the world called World Population Profile. Other sources, such as the Population Reference Bureau's World Population Data Sheet or the World Bank's World Development Indicators, list the total population of most countries of the world but do not provide age and sex specific numbers.

Population estimates may also be accessed from various Internet sites, including:
- United Nations population projections
- U.S.Census Bureau
- Population Reference Bureau

7.1.5.2.3 Total fertility rate

Using the editor
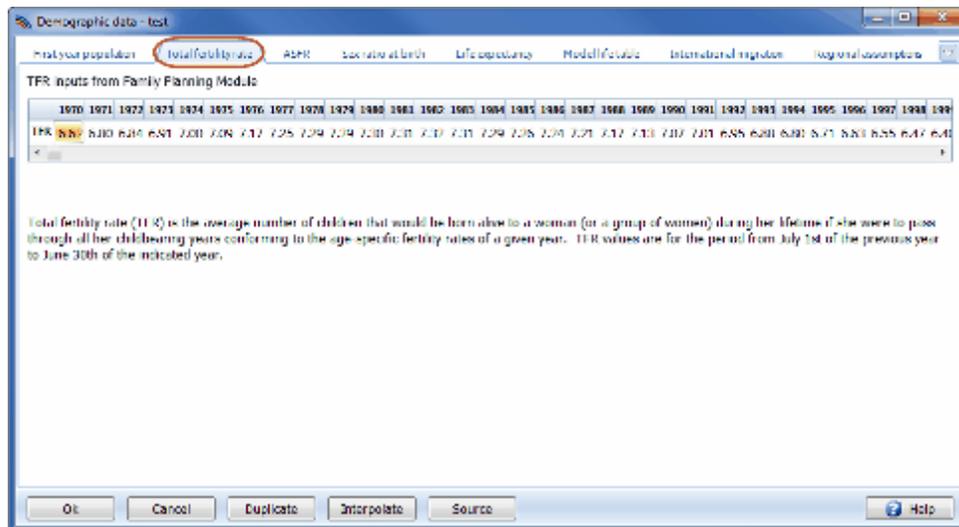
This editor can be found on the "Total fertility rate" tab under Demographic data and is used to enter the base year total fertility rates (TFRs) and the assumed future TFRs. The first few years will be shown on the screen. To see all of the years, use the scroll bar to scroll to the left or right.

If you selected a country or region when creating the projection, you will see country specific default data displayed, however you have the option to change these values.

If you want to keep the TFR constant at the base year value, you can enter the base year value and then use the "Duplicate" button; duplication may be done for any interval of time.

You may want to enter a TFR value for the first year and the last year and interpolate between these values to fill in the intervening years; interpolation may be done for any interval of time.

for instructions on how to use the Duplicate and Interpolate features.

Base year estimates

The Total Fertility Rate (TFR) is the number of live births a woman would have if she survived to age 50 and had children according to the prevailing pattern of childbearing at each age group. It is not an average of the number of live births for currently living women. Rather, it is a synthetic measure that expresses the current level of fertility in terms of the average number of live births that would occur per woman if the current age-specific fertility rates remained constant and all women survived to age 50.

Estimates of the TFR are available from a number of sources. The best sources will be national fertility surveys, which have been conducted by most countries. A large number have been conducted under a series of international projects, including the Demographic and Health Surveys (DHS), the Centers for Disease Control and Prevention (CDC) Fertility Surveys, the Contraceptive Prevalence Surveys (CPS) and the World Fertility Surveys (WFS). Information from these and other national surveys is collected and reported in a variety of sources, including summary reports from the DHS, the Population Reference Bureau's World Population Data Sheet, and the World Bank's World Development Indicators.

Future assumptions

An assumption about the future TFR is required for most population projections. However, if the population projection is combined with a family planning projection, then the future value of the TFR may be determined by the impact of the family planning program.

There are several options for setting the TFR projection.

1. **National projections.** Many countries have official population projections that include assumptions about the future course of their TFRs, often with several variants. If population projections are being made for planning purposes, it is often recommended that the official assumptions and projections be used.

2. **National goals**. Many countries have national population goals that often include the TFR. It may be useful to use these goals as a starting point for projections. One projection may assume that the TFR goal is achieved, while others may examine the effects of a delay in achieving the goal. Sometimes goals are expressed in terms of crude birth rates, population growth rates, or contraceptive prevalence rates instead of TFR. In these cases, different TFR assumptions may be used to discover a TFR projection that is consistent with the national goals for these other indicators.

3. **Published projections**. The population projections prepared by the United Nations Population Division and reported in World Population Prospects include three assumptions (low, medium and high) about future fertility for each country included in the report. These fertility assumptions may be used. The disadvantage to using these projections is that it is not clear how the "low," "medium" and "high" assumptions have been determined, but the UN generally considers the "medium" variant to be the most likely. The U.S. Census Bureau projections also contain a set of TFR assumptions.

4. **Recent trends and international experience.** If information is available on the TFR for several years, it may be useful to analyze the trends in TFR and to develop a future assumption based on continuing past trends. It should be noted, however, that past trends cannot be expected to continue for very long into the future. TFR rarely declines at a constant pace throughout an entire demographic transition. Rates of decline are often slow at first, increase during the middle of the transition, and slow again as they approach replacement level fertility.

5. **Socioeconomic development and population program effort.** Studies have shown that the pace of fertility decline is related to the level of socioeconomic development of a country and the amount of effort put into the family planning program. These studies are summarized in Table 1, which shows the decline in the TFR as a function of these two factors. This experience can be used to develop realistic assumptions about the rate at which fertility could decline in the future in any given country. Table 1 shows that the most rapid fertility declines experienced between 1978 and 1990 were for countries with strong family planning programs and high levels of socioeconomic development during the 1980s.

Table 1: Declines in TFR in 1990s by Level of Program Effort During 1994-1999 and Socioeconomic Setting

Socioeconomic Setting	Program Effort, 1994-1999								Overall Average
	Strong		Moderate		Weak		Very Weak/None		
High	Mexico	0.37	Chile	0.10	Brazil	0.25	Costa Rica	0.36	
	Mauritius	0.24	Trinidad	0.45			Uruguay	0.09	
	Colombia	0.21	and Tobago				Venezuela	0.31	
	Jamaica	0.26	Panama	0.08			Argentina	0.21	
	Korea, Rep	0.18	Uzbekistan	0.72			Kazakhstan	0.36	
	Malaysia	0.36	*Average*	*0.34*			*Average*	*0.27*	High
	Average	*0.27*							0.28
Upper Middle	Tunisia	0.81	Dominican	0.28	Ecuador	0.42	Guyana	0.10	
	Sri Lanka	0.30	Republic		Namibia	0.45	Mongolia	0.70	
	Iran	1.80	Syria	0.79	Lebanon	0.54	*Average*	*0.40*	
	Peru	0.50	Turkey	0.40	Jordan	0.76			
	Thailand	0.15	Algeria	0.97	Oman	1.05			
	Average	*0.71*	Egypt	0.49	Paraguay	0.38			
			El Salvador	0.35	Nicaragua	0.49			Upper
			Philippines	0.50	Honduras	0.62			Middle
			South Africa	0.50	*Average*	*0.59*			0.58
			Average	*0.54*					
Lower Middle	India	0.35	Ghana	0.70	Bolivia	0.48	Congo	-	
	Zimbabwe	0.60	Senegal	0.66	Zambia	0.20	Nigeria	0.46	
	Morocco	0.55	Pakistan	0.35	Guatemala	0.47	Mauritania	0.10	
	Kenya	0.80	Lesotho	0.38	Cameroon	0.60	*Average*	*0.19*	
	China	0.12	*Average*	*0.52*	Côte d'Ivoire	0.70			
	Indonesia	0.40			*Average*	*0.49*			Lower
	Vietnam	0.80							Middle
	Average	*0.52*							0.46
Low	Bangladesh	0.45	Mali	-	Uganda	-	Benin	0.40	
			Tanzania	0.40	Malawi	0.30	Ethiopia	0.30	
			Nepal	0.30	Niger	-	Mozambique	0.30	
			Average	*0.23*	Central		Madagascar	0.10	
					African		Chad	-	
					Republic	0.30	Yemen	0.50	
					Haiti	0.40	Laos	0.50	
					Average	*0.20*	Sudan	0.40	
							Cambodia	0.20	Low
							Average	*0.30*	0.27
Overall Average		0.49		0.44		0.44		0.28	0.41

Source: Ross and Stover, 2001.

7.1.5.2.4 Age-specific fertility rate

Using the editor

This editor is used to set the distribution of fertility by age.

To specify the age distribution you can either use the model table or enter your own data from the keyboard. If you selected a country, you will see default country-specific values in the editor. If you wish to enter your own data for the age distribution of fertility, then make sure "Enter from keyboard" is selected. Enter your data into the appropriate cells. The total for each year will be calculated and displayed in the last row. The total for each year should be equal to 100 before you leave this editor. If even one column does not total to 100, you will see a warning message when you try to exit this editor. The message will say "At least one column total < 99.9. Return to editor?" or "At least one column total > 100. Return to editor?" If you get either of these messages you should click on "Yes" to return to the editor and correct the inputs. The "Normalize" button can be used to adjust the selected values so they add up to 100 in a proportional manner.

Click the "Comparison" button to see a table comparing the age specific fertility distribution of values in the editor with those in the model tables. Initially the base year will be displayed. Click the "Next year" button to advance the values in the table and the "Prev year" button to return to earlier years. To see a graph instead of a table, click the "Chart" button.

Why is Age-Specific Fertility Rate (ASFR) important?

In addition to the TFR, the age distribution of fertility is also required to make a population projection. In DemProj, this information is entered as the percentage of lifetime fertility that occurs in the five-year age groups 15-19, 20-24, 25-29, 30-34, 35-39, 40-44, and 45-49.

Age at childbearing is relevant for reproductive health. The age of the mother may be of particular concern to the wellbeing of the infant, with younger ages being associated with risks of premature delivery or protracted labor, and older ages with congenital malformations. The mother herself also may be adversely affected by extremes in age of childbearing. Women who bear children at younger ages may be physically and socially unprepared, and older mothers may face aggravated anemia or hemorrhagic complications.

Use of Fertility Models in Population Projections

In DemProj, model schedules are used to generate age patterns in conjunction with levels of fertility, mortality, and migration.

Projected fertility is affected by certain age characteristics. For example, appropriate fertility rates need to be assigned by age group, as those groups vary in size, which contributes to the size of the population being projected to the next time period. In addition, some implications of population projections follow from the age of the mothers as they bear children.

Fertility Surveys

Information on the initial age distribution of fertility is usually available from national fertility surveys. It may be reported as age-specific fertility rates (the number of live births per 1000 women in the age group) rather than as the percent distribution of fertility. Data on age-specific fertility rates can be converted to the required percentage distribution by dividing each age-specific fertility rate by the sum of all the age-specific fertility rates. This calculation is illustrated in Table 2.

Table 2. Calculation of the Distribution of Fertility by Age Group from Age-Specific Fertility Rates

Age Group	Age-Specific Fertility Rate	Percent Distribution for Fertility by Age Group
15-19	84	10.9
20-24	202	26.3
25-29	203	26.4
30-34	143	18.6
35-39	97	12.6
40-44	34	4.4
45-49	5	0.7
Total	768	100.0

From a review of hundreds of fertility shapes, we know that fertility patterns tend to concentrate and to shift to younger years as fertility declines (Horne and El-Khorazaty, 1996). In Figure 1, for example, the normalized fertility distributions for Bangladesh show a switch from a traditional plateau distribution in 1975 to a rather peaked distribution in 1993-94. For Taiwan, Figure 2 shows a shift from a homogenous distribution to one where fertility occurs almost entirely among women in their twenties.

Figure 1: Shift in Fertility Distributions - Bangladesh: 1975 to 1993-94
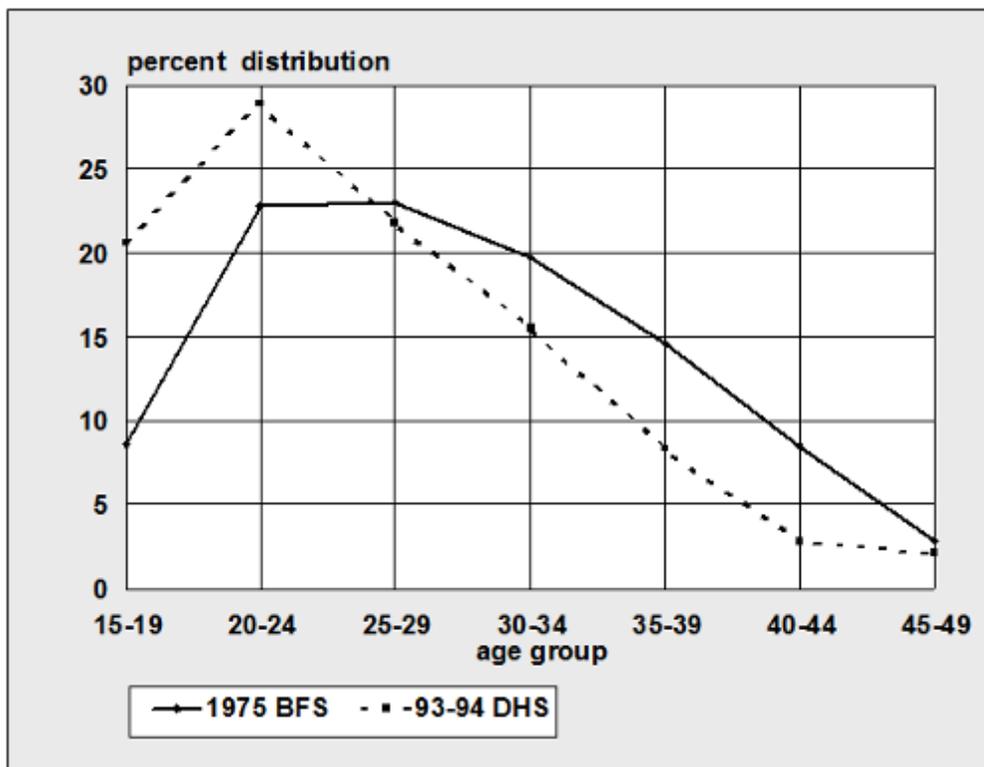
Figure 2: Shift in Fertility Distributions - Taiwan: 1956 to 1983
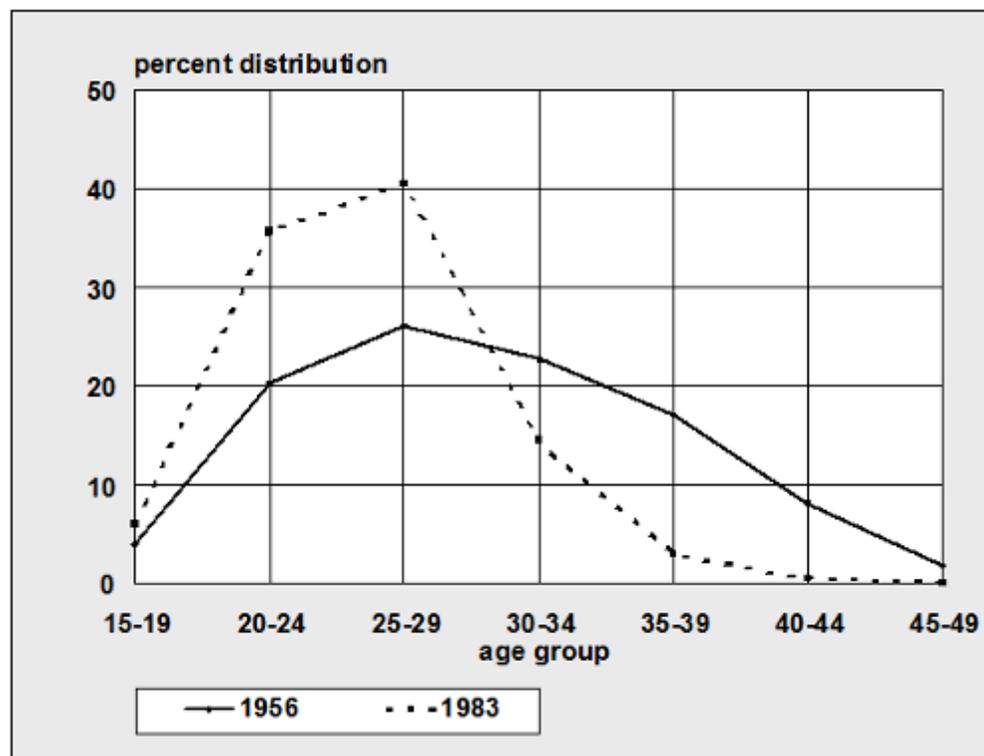
Regionality and Model Fertility Patterns: the United Nations Model Schedules

Aspects of fertility that can vary from one locale to another include: how concentrated the fertility rates are, how fast this concentration occurs, and how young a shift is displayed. The United Nations Population Division has developed regional patterns to describe the shift in childbearing as fertility changes, using patterns labeled as sub-Saharan Africa, Arab nations, and Asia. In Table 3, the fertility distributions by various total fertility rates are given for each of the four patterns. Figure 3 depicts the shifting fertility distribution for the sub-Saharan Africa model for changing fertility levels. It shows a relatively flat distribution of fertility across ages for high level of TFR, and an increasingly peaked distribution (reaching a maximum in the age group 2024) when TFR is 2 or 3.

Table 3: UN Model Tables of the Age Distribution of Fertility

TFR	15-19	20-24	25-29	30-34	35-39	40-44	45-49	Total
Sub-Saharan Africa								
2	8.2	35.4	29.9	17.4	7.2	1.7	0.1	100
3	14.0	31.1	24.7	16.6	9.2	3.6	0.6	100
4	14.9	25.9	22.1	17.1	11.7	6.4	1.8	100
5	16.1	25.4	22.0	17.0	11.6	6.2	1.6	100
6	16.4	24.7	22.1	17.3	11.7	6.2	1.5	100
7	14.7	23.5	21.9	17.9	12.8	7.2	2.0	100
Arab Countries								
2	7.2	31.1	30.3	19.7	9.0	2.4	0.2	100
3	6.6	29.1	29.8	20.7	10.4	3.2	0.2	100
4	7.6	24.4	26.0	21.1	14.2	6.9	1.4	100
5	8.5	23.1	24.9	21.0	14.2	6.9	1.4	100
6	8.8	21.9	24.3	21.1	14.8	7.5	1.6	100
7	7.8	21.7	25.1	21.9	15.0	7.2	1.4	100
Asia								
2	2.8	31.1	38.4	21.1	5.9	0.7	0.0	100
3	2.4	23.5	33.7	25.6	11.9	2.8	0.1	100
4	3.8	20.8	27.9	24.6	15.7	6.3	0.8	100
5	5.6	21.4	26.6	23.3	15.4	6.7	1.0	100
6	7.9	22.8	26.2	22.0	14.2	6.1	0.9	100
7	11.8	24.1	24.1	19.5	13.0	6.3	1.3	100
Average								
2	6.1	32.5	32.9	19.4	7.4	1.6	0.1	100
3	7.7	27.9	29.4	21.0	10.5	3.2	0.3	100
4	8.8	23.7	25.3	20.9	13.9	6.5	1.3	100
5	10.1	23.3	24.5	20.4	13.7	6.6	1.3	100
6	11.0	23.1	24.2	20.1	13.6	6.6	1.3	100
7	11.4	23.1	23.7	19.8	13.6	6.9	1.6	100

Source: *World Population Prospects,* as assessed in 1973.

Figure 3: Fertility Distribution by TFR: UN Sub-Saharan Africa Pattern
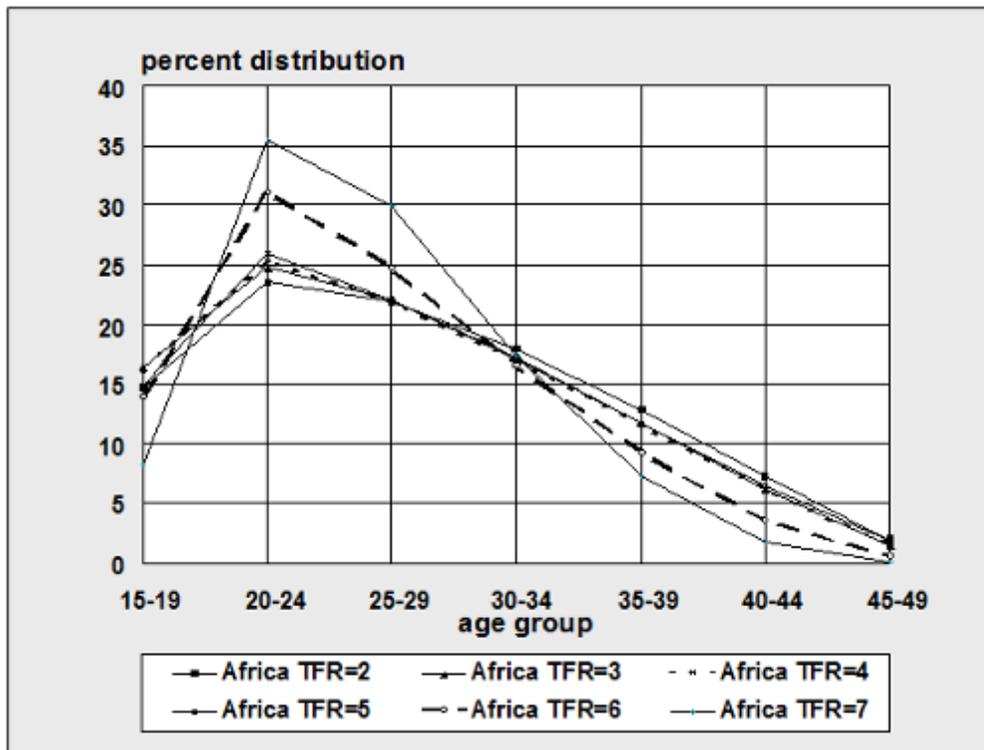
The differences among the model fertility tables can be seen in Figure 4. In this figure, the age pattern of fertility is compared for all four tables at a TFR of four. The model table for sub-Saharan Africa has a higher proportion of fertility concentrated in the youngest age groups, while the Asia table has the oldest pattern.

Figure 4: Comparison of Model Fertility Tables at a TFR of 4.0

percent of lifetime fertility

Legend: Sub-Saharan Africa — Arab — Asia - - -Average
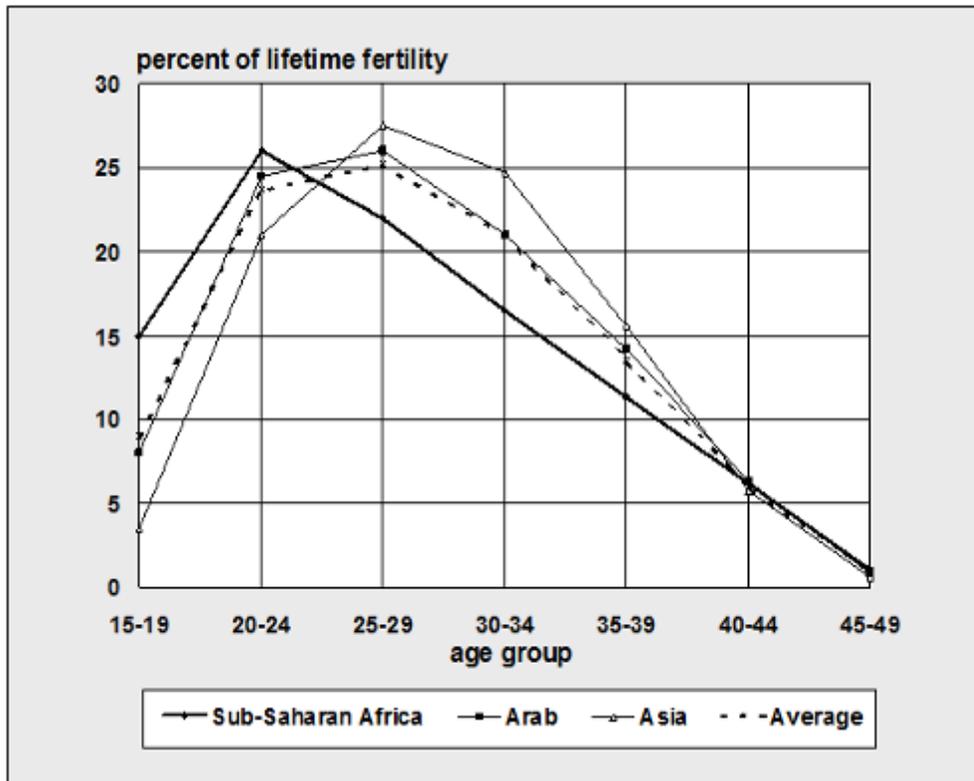
However, regions are not as well associated with fertility patterns as they are with mortality patterns. Mortality patterns by region have been employed long and successfully to analyze and project mortality. Regional mortality forces that tend to match up with geography are climate, country proximity, culturally based sex roles, diet, medical practices, political stability, etc. Fertility is subject to relatively more forces that are primarily not biological and therefore are harder to aggregate by geographic area than is true for mortality.

Figures 5 and 6 illustrate the inconstancy of regional patterns for projecting fertility. They show that the Asia pattern was an adequate model for Bangladesh in 1975 when the TFR was 6.3, but by 1989, when the TFR had dropped to 5.1, the Asia model was far from adequate. Bangladesh's status then was better matched by the sub-Saharan Africa pattern.

Figure 5: Shift in Fertility Distributions – Bangladesh and UN Asia Pattern
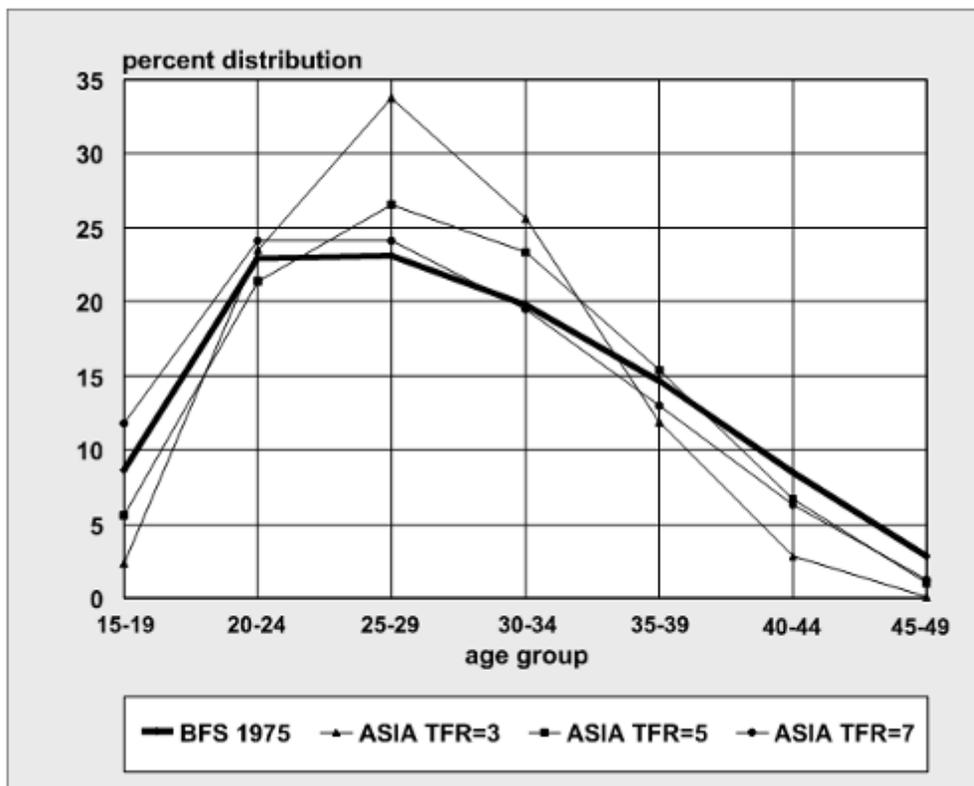
Figure 6: Shift in Fertility Distributions – Bangladesh and UN Sub-Saharan Africa Pattern
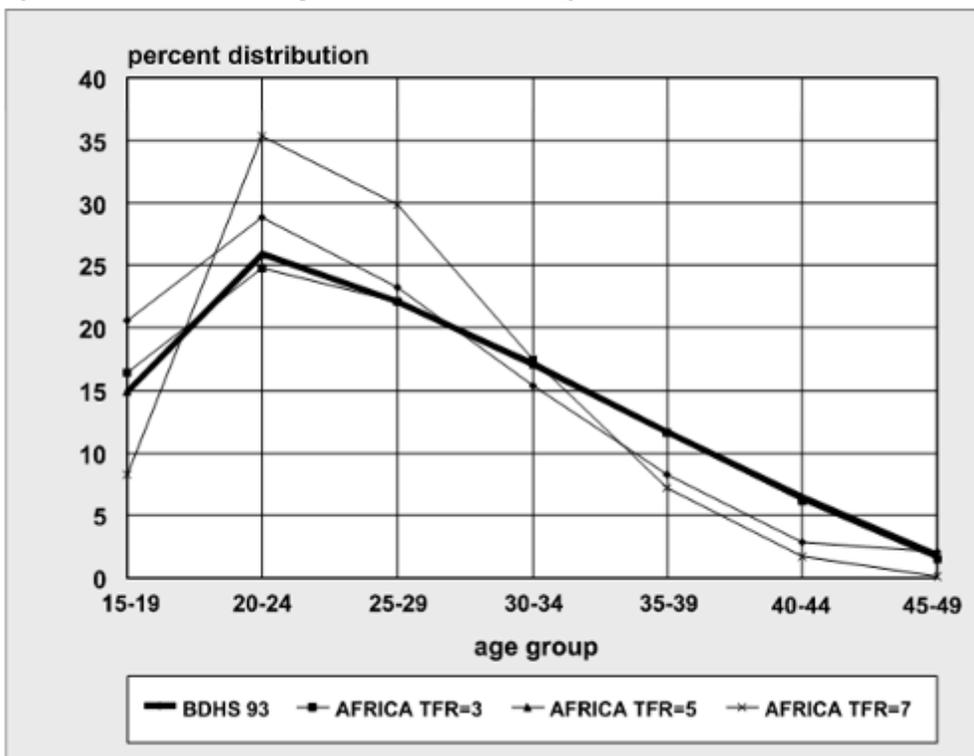
In sum, DemProj users should **not** assume that because their country lies geographically within Asia or sub-Saharan Africa, or is an Arab country, they should necessarily choose that respective region. Users should first check their country or region's initial fertility distribution against those given in Table 3. If these shapes do not fit, or the country lies outside of those three regions, the Average pattern is recommended.

Combining Data from Fertility Surveys with Model Tables

The most common situation is one where data on the distribution of fertility by age are available for the base year. However, most projections include changing TFR in future years. The model tables are useful for estimating how the fertility pattern will change as fertility changes. This raises the problem of how to use the base year survey data but still take advantage of the model tables for future values of TFR. The simplest solution is to use the fertility survey data for the base year and the model table values for the final year of the projection or the year in which fertility stops changing. Interpolating between these two points will yield a fertility distribution that takes advantage of both methods. To get the most out of this method, the interpolation for any particular year should be based on how much the TFR has changed within the projected range, and not on the year itself.

7.1.5.2.5 Sex ratio at birth

Using the editor
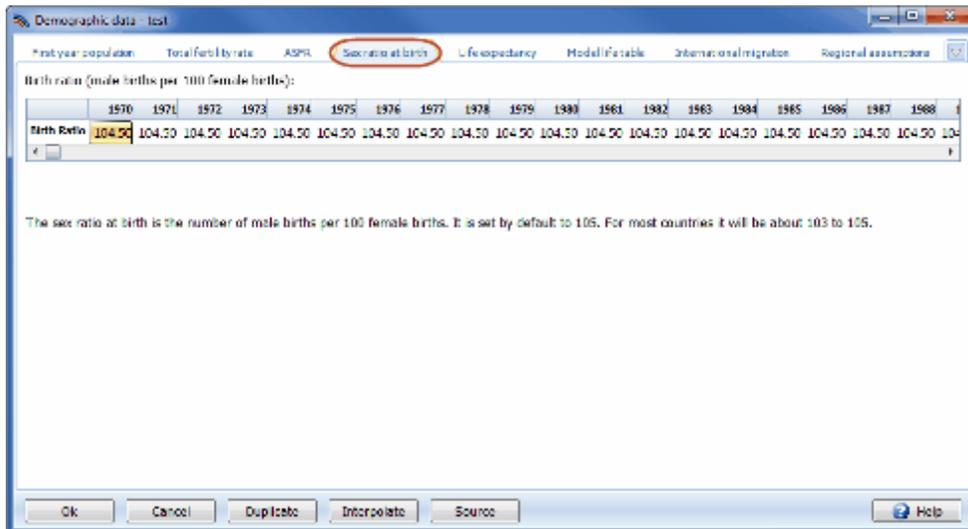
The sex ratio at birth is the number of male births per 100 female births. It is set by default to 105. For most countries it will be about 103 to 105. If you selected a country or region when you created the projection, you will see the default country specific values displayed.

7.1.5.2.6 Life expectancy

Using the editor
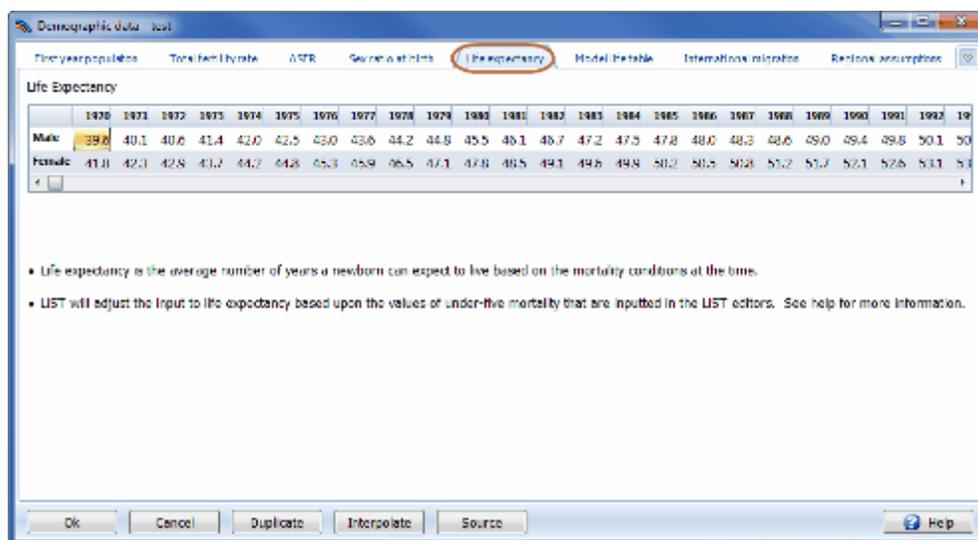
If you selected a country or region when you created the projection, you will see the default country specific values displayed in the editor. You can scroll to the right and left using the scroll bar to see the values for all years of the projection. If you wish to edit these values, you can keep them constant over time using the Duplicate button or can select years and interpolate them from the start year to the end year using the Interpolate button. Click here for instructions on how to use the Duplicate and Interpolate features.

Base year estimates

Life expectancy at birth is the average number of years that a cohort of people would live, subject to the prevailing age-specific mortality rates. It is a useful measure that summarizes in one indicator the effect of age-specific mortality patterns. Life expectancy can be calculated from vital statistics on deaths if reporting is complete. In the developing world, death registration is not usually complete enough to be used for this purpose. Estimates of life expectancy are usually derived instead from large scale surveys or censuses. The best source of information on life expectancy will usually be national reports prepared by analyzing these surveys. If national estimates are not available, life expectancy estimates may be obtained from a variety of other sources, including the United Nation's World Population Prospects or the Demographic Yearbook, the U.S.Census Bureau's World Population Profile, the World Population Data Sheet of the Population Reference Bureau, or the World Bank's World Development Indicators.

Future Assumptions

An assumption about future levels of life expectancy at birth is required for all population projections. There are several options for setting the life expectancy assumption.

1. **National projections.** Many countries have official population projections that include assumptions about the future course of life expectancy, often with several variants. If population projections are being made for planning purposes, it is often recommended that the official assumptions and projections be used.

2. **National goals.** Many countries have national population goals that include life expectancy. It is often useful to use these goals as a starting point for projections. In one projection it may be assumed that the life expectancy goal has been achieved, while in others model users may

examine the effects of a delay in achieving the goal. Sometimes goals are expressed in terms of crude death rates or population growth rates instead of life expectancy. In these cases, different life expectancy assumptions may be tried to discover a projection that is consistent with the national goals for these other indicators.

3. **United Nations and U.S. Census Bureau projections.** The population projections prepared by the United Nations Population Division and reported in World Population Prospects include assumptions about levels of life expectancy for each country reported. These assumptions may be used. The U.S. Census Bureau projections also contain a set of life expectancy assumptions.

4. **Recent trends and international experience.** If information is available on life expectancy for several years, it may be useful to analyze the trends and develop a future assumption based on continuing past trends. It should be noted, however, that past trends cannot be expected to continue for very long into the future. Life expectancy rarely increases at a constant pace throughout an entire demographic transition. Rates of decline are often slow at first, increase during the middle of the transition, and slow again as they approach high levels.

5. **United Nations model schedule.** In preparing its population projections every two years, the United Nations Population Division uses a model schedule of changes in life expectancy. This schedule assumes that life expectancy at birth, for both males and females, increases by 2.0 to 2.5 years over each five-year period when life expectancy is less than 60 and then increases at a slower rate at higher levels. Table 4 shows the working model used in the United Nations population projections.

Table 4: UN Working Model of Life Expectancy Improvement During a Five-Year Period

Initial Life Expectancy	Fast Rise		Middle Rise		Slow Rise	
	Male	Female	Male	Female	Male	Female
55.0-57.5	2.5	2.5	2.5	2.5	2.0	2.0
57.5-60.0	2.5	2.5	2.5	2.5	2.0	2.0
60.0-62.5	2.5	2.5	2.3	2.5	2.0	2.0
62.5-65.0	2.3	2.5	2.0	2.5	2.0	2.0
65.0-67.5	2.0	2.5	1.5	2.3	1.5	2.0
67.5-70.0	1.5	2.3	1.2	2.0	1.0	1.5
70.0-72.5	1.2	2.0	1.0	1.5	0.8	1.2
72.5-75.0	1.0	1.5	0.8	1.2	0.5	1.0
75.0-77.5	0.8	1.2	0.5	1.0	0.3	0.8
77.5-80.0	0.5	1.0	0.4	0.8	0.3	0.5
80.0-82.5	0.5	0.8	0.4	0.5	0.3	0.3
82.5-85.0	–	0.5	–	0.4	–	0.3
85.0-87.5	–	0.5	–	0.4	–	0.3

Life Expectancy and AIDS

In a number of countries, the AIDS epidemic has had a significant impact on mortality. It affects both life expectancy and the age and sex pattern of mortality. This health concern raises two problems for population projections. First, in countries with high HIV prevalence, the future course of the AIDS

epidemic will be the single largest determinant of future life expectancy. Second, the age pattern of mortality will depart significantly from the patterns described in the model life tables. Therefore, in countries with adult HIV prevalence greater than a few percent, it is best to consider the effects of AIDS explicitly in the population projection. These effects cannot be incorporated simply by changing the life expectancy assumption since the age pattern of mortality is also affected (AIDS deaths are concentrated in the age groups of 15-49). The recommended approach is to first develop a population projection that ignores the effect of AIDS, then to make assumptions about the future level of adult HIV prevalence and let Spectrum calculate the effects of AIDS on the population projection. Such projections can be prepared using DemProj and AIM, the AIDS component of Spectrum.

Most of the steps required to prepare a population projection that excludes the effects of AIDS are the same as for any other projection. However, preparation of the life expectancy assumption may be different. If AIDS has not yet contributed significantly to mortality, then estimates of current life expectancy can be used. However, in many countries AIDS has already affected life expectancy. In these cases, it is necessary to prepare an estimate of life expectancy that excludes the impact of AIDS. This could be done by removing AIDS deaths from the schedule of deaths by age and recalculating life expectancy. However, AIDS deaths are usually greatly under-reported, making this approach questionable.

An alternative approach is to start with an estimate of life expectancy for some year before a significant number of AIDS deaths occurred. Then estimate how life expectancy would have changed from that year forward to the base year of the projection in the absence of AIDS. This could be done by extrapolating the historical trend or by using the United Nations model schedule. Life expectancy in the absence of AIDS can be projected into the future in a similar manner.

It should be noted that the life expectancy assumptions reported in World Population Prospects and World Population Profiles include the effect of AIDS. In countries where AIDS is a serious problem, these life expectancy projections cannot be used to create a population projection in the absence of AIDS. Both organizations do produce special tables that show the nonAIDS life expectancy assumptions that can be used in DemProj.

Adjustment to life expectancy when LiST is active

DemProj life expectancy is based upon a model life table. When LiST and DemProj are originally loaded with default data the under-five mortality implied by DemProj and the under-five mortality input to LiST are inconsistent. The life table of DemProj is shifted upward or downward based upon this inconsistency to make the values consistent. The adjustment is made only after the first result from LiST is requested. If you would like to have a particular life expectancy at your baseline, you are required to make adjustments to the default life expectancy in DemProj in an iterative process. After each adjustment that you make to DemProj, LiST will make another adjustment to life expectancy. After iterations you will eventually arrive at a life expectancy that you desire.

7.1.5.2.7 Model life table

Using the editor
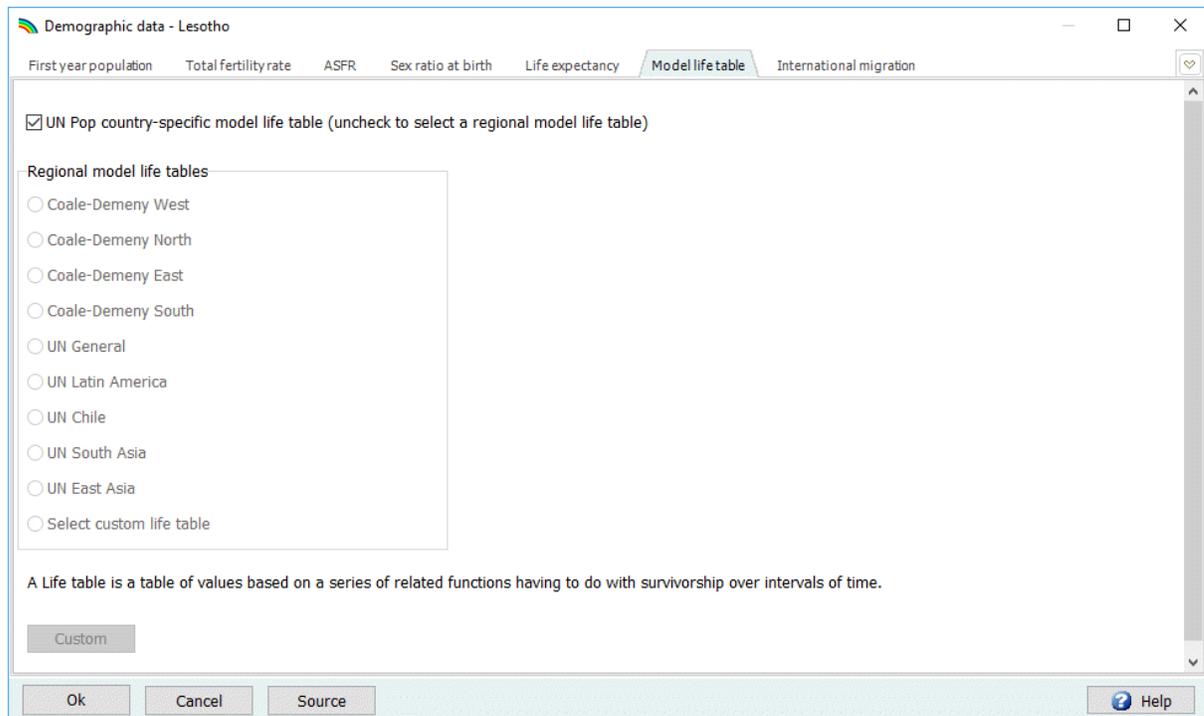
This editor allows you to specify which model life table to use for your projection. The default is to use the UN POP model life table which contains country specific data. The age-specific mortality rates needed by Spectrum will be calculated based on the life expectancy and model life table when you leave the editor.

Model Mortality Tables

The mortality input to DemProj, life expectancy at birth, indicates overall mortality in a population. But Demproj also needs the **pattern** of mortality in order to produce mortality rates by age group. Specifically, the rates required by DemProj are survival ratios, which will survive one age group into the next five-year group.

The majority of countries to which DemProj has been applied have had no complete, empirical life tables - and life tables are what yields survival ratios, or s_x. Even if there were such tables, generally little is known about how the pattern of mortality would evolve, given projected changes in mortality levels. In addition, entering data for a life table function for all 18 age groups is burdensome. So for both parsimony and consistency with studied patterns, DemProj employs model life tables.

Regional Model Life Tables

Two sets of model life tables are employed by DemProj: the Coale-Demeny (Coale, Demeny, and Vaughan, 1983) model tables and the United Nations tables for developing countries (United Nations, 1982). These two sets differ in (1) the algorithm they use to generate the mortality schedules, and (2) the empirical data sets from which they were drawn (Coale-Demeny: life tables from Europe and other industrialized regions from the first half of the 20th century; the United Nations: life tables from developing countries from the second half of the 20th century).

But the two model sets are similar in one important respect: they contain regional families that are distinguished by underlying causes of death. Referring to the regions from Europe whose life tables provided distinct patterns, the Coale-Demeny families are known as: North, East, South, and the non-idiosyncratic West. The United Nations families name very specific regions—Latin America, South America, Chile, South Asia, East Asia, plus the generic General. Figures 7 through 9. In each, the probability of dying during an age interval q_x, is plotted against age groups. (A semi-log scale is used to highlight important differences.)

In Figure 7, the probabilities of dying are generated for the Coale-Demeny West model (for females), for five mortality levels. The range in mortality levels is from very low [e(0)=35] to rather high [e(0)=75]. In this series, the effects of the changing mortality levels are most noticeable in the younger age groups.

Figure 7: Model Life Table Mortality Probabilities – Coale-Demeny West Female Models Table: Compared by Level of Life Expectancy
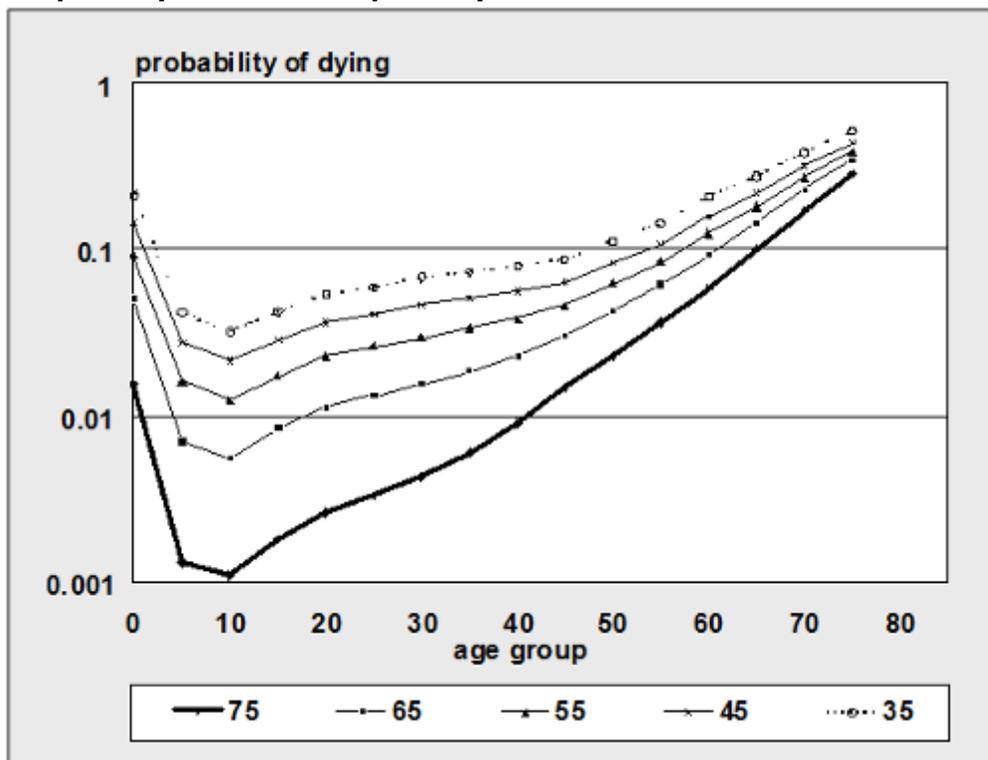
In Figure 8, the q_x mortality probabilities are plotted for the four Coale-Demeny regions for females having the same life expectancy at birth: 45 years. The North pattern has the highest death rates for infants and children; the West has high death rates for age 15 and higher.

Figure 8: Model Life Table Mortality Probabilities – Coale-Demeny Female Model Table Families: Comparison by Family at e(0) = 45
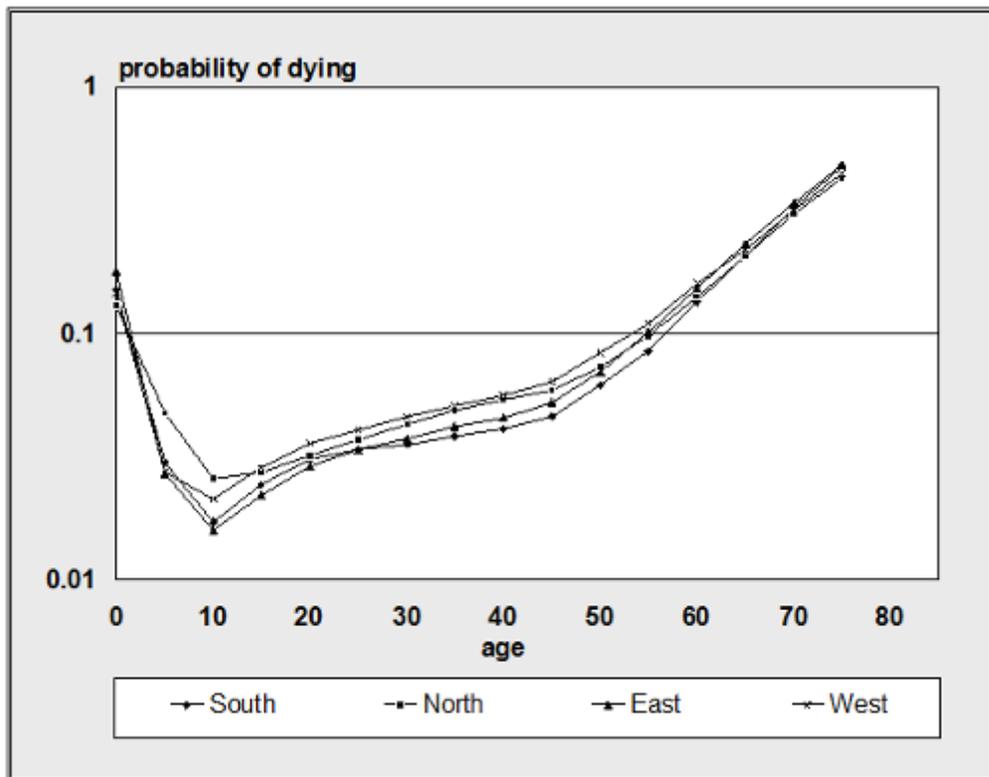
In Figure 9, the mortality probabilities are graphed for the five United Nations families, again for females with a life expectancy at birth of 45 years. There is greater differentiation between United Nations than between Coale-Demeny families. One extreme is given by the East Asian pattern, which has a rather high level of adult mortality and a relatively low level of under age 10 mortality. The other extreme is the South Asian family, which has a distinctly low adult mortality pattern (between ages 10 and 50), and a relatively high child mortality pattern.

Figure 9: Model Life Table Mortality Probabilities – United Nations Female Model Table Families: Comparison by Family at e(0) = 45
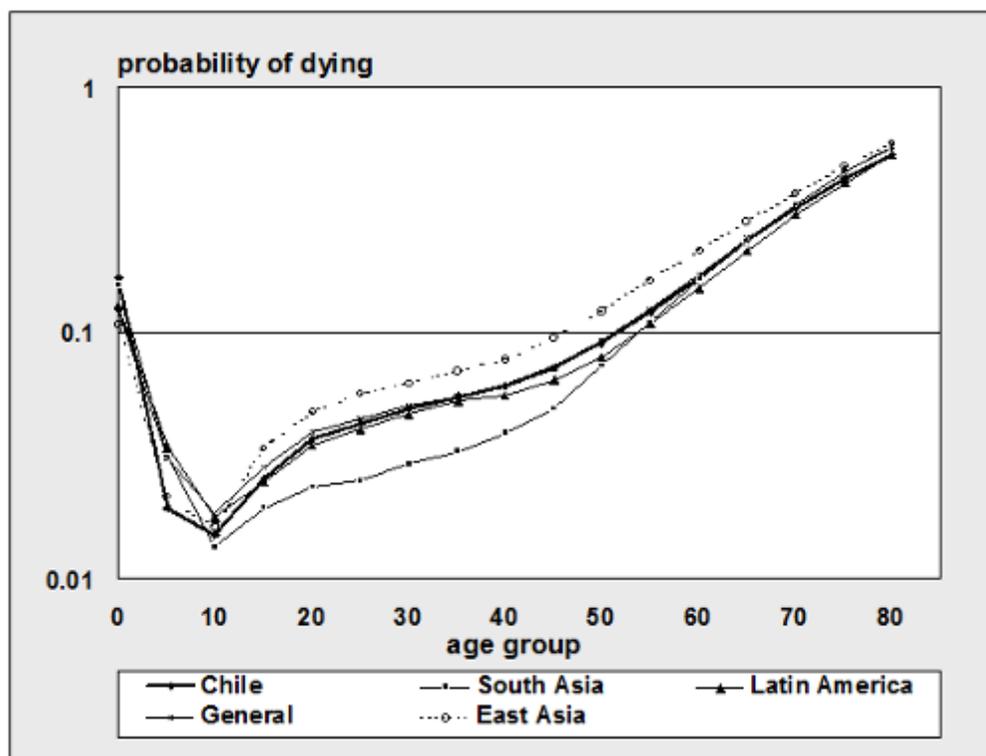
Selecting a Model Life Table

There are several approaches to determining the most appropriate life table for a particular country or region in terms of the mortality level and pattern.

1. The best way is to compare data on age-specific mortality for that country with the mortality pattern at the corresponding level of life expectancy for each of the model tables. The appropriate table will be the one that most closely matches the actual experience.

2. The best model life table may already have been determined by demographers from that country. Consulting with them or reviewing reports or official projections may indicate the model table that the national demographers consider the best fit.

3. If neither of the first two options is possible, a third option is to compare the crude death rate and infant mortality rate that would result from choosing each model life table with the actual estimates of these indicators. The table that provides the closest fit may be the most appropriate. Spectrum will generate corresponding crude death and infant mortality rates for the first year of the projection automatically as a guide to choosing the best table.

Modifying the Model Life Tables

Every effort has been made to make DemProj as easy to use as possible. This ease of use comes at the expense of some flexibility. There may be times when it is desirable to determine an age-specific schedule of mortality without using these model life tables. DemProj does not contain an editor to allow interactive entry of custom tables of age-specific mortality and the majority of the data DemProj contains

are survival probabilities, not mortality rates. However, DemProj does allow for the use of a custom life table. A custom table can be created by editing the custom life table file.

In a typical configuration, the computer files containing the information on model life tables are contained in the directory C:\Spectrum\DP. All model life table files for females have the extension ".f" while all male files have the extension ".m". The Coale-Demeny tables are named "cdnorth," "cdsouth," "cdwest" and "cdeast." The United Nations tables are named "unchile," "unea," "ungen," "unla," and "unsa." The custom tables are named custom.f and custom.m. These files can be edited with any editor or word processor that can produce ASCII or text files to enter the desired patterns.

The format of the model life table files is as follows:

- Row 1: life expectancy at birth.
- Rows 2 through 81: one-year survival ratios for ages 0 to 79.
- Row 82: the proportion of the age group 80+ that will survive to the next year.
- Row 83: the infant mortality rate.
- Row 84: the child mortality rate (1-4).

In each row, the values in the columns correspond to the life expectancy shown in that same column in the first row.

Any of the figures in these files, including life expectancy, may be changed to produce a new life table. To produce an entire schedule of age-specific mortality rates for a particular projection, enter the life expectancy for each year or five-year interval in the first row and the corresponding survival rates in the rows below. The life expectancy values do not need to be round numbers, nor do they need to be equally spaced; however, they do need to be arranged from the lowest value in the first column to the highest value in the last column. Once the new values are entered, save the table as a text file using a unique name, and then specify the custom table and enter this name when creating the DemProj projection file.

7.1.5.2.8 International migration

Using the editor
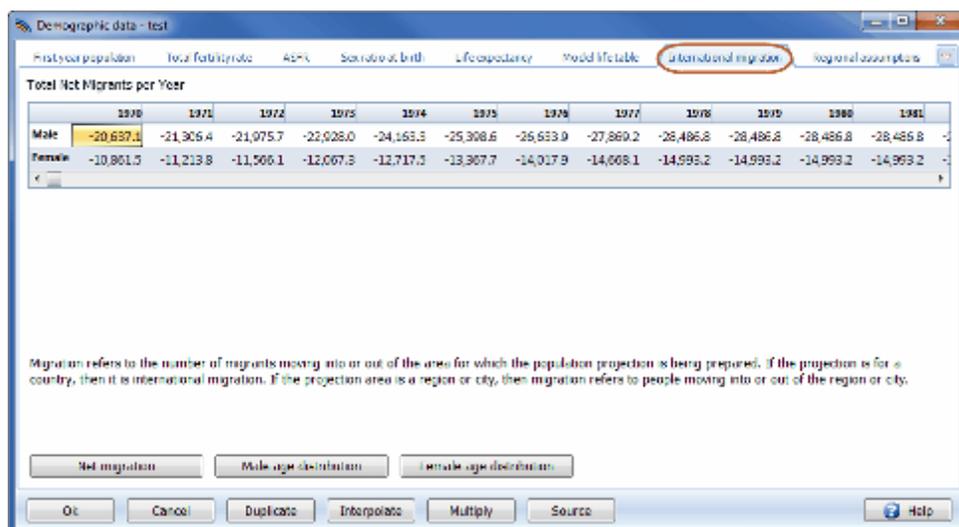
Migration refers to the number of migrants moving into or out of the area for which the population projection is being prepared. If the projection is for a country, then it is international migration. If the projection area is a region or city, then migration refers to people moving into or out of the region or city.

Migration is specified through two inputs. The first is the net number of migrants, by sex and year. If the net flow is outward, then net migration should be a negative number. If the net flow is inward, then it should be positive. In most cases, information on migration will come from local sources, usually studies based on a national census. The United Nations report World Population Prospects does contain estimates and projections of total net migration, but they are not disaggregated by sex.

The second component of the migration assumption is the distribution of migrants by age for each sex. This information also needs to come from national studies. There are no simple model tables for patterns of migration by age; however, the United Nations has devised an approach to developing age and sex migration patterns. This approach is based on model schedules of gross migration developed by Castro and Rogers (described in United Nations 1989, pp. 65-69).

Net international migration is not a major component of population change in most countries. Often, migration can be ignored without a significant effect on the population projection. However, for special areas, such as cities, and for some countries, migration can be very important. Moreover, age and sex patterns of migration vary considerably. In Nairobi, for example, migrants to the city consist largely of young males seeking work. In other cities, such as Kinshasa, migrants to the city are composed primarily of entire families. In Jordan, there was a significant outflow of migrants during the oil boom in the Persian Gulf states of the 1970s and 1980s, but during the 1990s, there was a net inflow of migrants as families returned to Jordan due to reduced employment opportunities in the Gulf.

7.1.5.2.9 COVID-19 deaths

If you are using the latest demographic estimates from World Population Prospects 2022 then excess COVID-19 deaths are already included. However, if you are using something else you may want to add COVID-19 mortality directly. To do that, you first need to check the box 'Enter COVID-19 deaths' under DemProj > Projection parameters. Once you do that you will see a 'COVID-19 deaths' editor under DemProj > Demographic data. In this editor you can enter the total number of male and female deaths due to COVID-19 in 2020, 2021, 2022, 2023 and 2024. If you only enter totals then Spectrum will distribute those deaths by age according to a standard pattern derived from data on COVID-deaths by age for the United States. If you want to use a different pattern, click the buttons 'Male age distribution' and 'Female age distribution' and enter your own pattern. These patterns represent the percentage distribution of all deaths for each sex, so they should sum to 100. You can force the data to sum to 100 using the 'Normalize' button.

7.1.6   DemProj results

DemProj will calculate and display the population size by year. Projections can be examined in terms of total population or population by age, sex, and region. In addition, a number of demographic indicators can also be displayed. A complete list of indicators available is given below with definitions for those that are not obvious. Many of these definitions are taken from the *Population Handbook* (Population Reference Bureau, 1989); a complete glossary is contained in the Glossary of terms.

7.1.6.1   Population

- Total population size
- Population aged 0-4

- Population aged 5-14

- Population aged 15-49

- Population aged 15-64

- Population aged 65+

- Total net international migration

7.1.6.2   Fertility

- **Total fertility rate (TFR).** The average number of children that would be born alive to a woman (or a group of women) during her lifetime if she were to pass through all her childbearing years conforming to the age-specific fertility rates of a given year.

- **Gross reproduction rate (GRR).** The average number of daughters that would be born to a woman (or a group of women) during her lifetime if she passed through all her childbearing years conforming to the age-specific fertility rates of a given year. This is similar to the TFR except that it counts only daughters.

- **Net reproduction rate (NRR).** The average number of daughters that would be born to a woman (or a group of women) during her lifetime if she passed through all her childbearing years conforming to the age-specific fertility rates and age-specific mortality rates of a given year. This is similar to the GRR except that it includes the effect of mortality that would cause some women to die before completing their childbearing years.

- **Mean age of childbearing.** The average age of mothers at the time of birth.

- **Child-woman ratio.** The number of children under the age of five per woman of childbearing age (15-49).

7.1.6.3   Mortality

- **Life expectancy [e(0)].** The average number of years a person can expect to live based on the age-specific death rates for a given year. This is the calculated life expectancy at birth. If AIM is not being used, then this number will be the same as the input life expectancy. However, if AIM is being used, then the calculated life expectancy will include the impact of AIDS deaths. Therefore, it will be different from the input life expectancy.

- **Infant mortality rate (IMR).** The number of deaths to infants under one year of age per 1,000 live births.

- **Under-five mortality rate (U5MR).** The number of deaths to children under the age of five per 1,000 live births.

7.1.6.4   Vital events

- **Births.** The total number of annual births.

- **Deaths.** The total number of annual deaths.

- **Deaths by age.** The total number of annual deaths, broken down by age group**.**

- **Crude birth rate (CBR).** The number of live births per 1,000 population in a given year.

- **Crude death rate (CDR).** The number of deaths per 1,000 population in a given year.

- **Rate of natural increase (RNI).** The rate at which the population is increasing or decreasing in a given year due to the surplus or deficit of births over deaths, expressed as a percentage of the base population.

- **Annual growth rate (GR).** The rate at which the population is increasing or decreasing in a given year due to natural increase and net migration, expressed as a percentage of the base population.

- **Doubling time.** The number of years it would take for the population to double its current size at the current annual rate of growth.

7.1.6.5 Ratios

- **Sex ratio.** The number of males per 100 females in a population.

- **Dependency ratio.** The ratio of the economically dependent part of the population (those aged 0-14 and 65 and over) to the productive part (those aged 15-64).

7.1.6.6 Age groups

- **All age groups**. The size of the population for all age groups.

- **Defined age group.** The size of the population in a user-defined age group.

- **Median age.** The age that divides a population into two numerically equal groups.

Displaying all age groups in DemProj

If you wish to see the population size by age and sex, choose "Results," "Age groups," and "All age groups." You can display the information as a table or as a population pyramid (see glossary) showing either numbers of people ("Pyramid (numbers)") or the percent distribution by age and sex ("Pyramid (percent)").
The pyramid display always shows two pyramids. If you are using a single projection, then the pyramid on the left will always be for the base year. You can change the year for the pyramid on the right by clicking one of the buttons at the bottom of the screen to advance the pyramid one year ("Next"), show the previous year ("Previous"), show the first year ("First year") or show the last year ("Last year").

If you have two projections loaded, then the pyramid on the left will display the first projection and the one on the right will show the second projection. Both pyramids will display the same year; using the "Next" and "Previous" buttons will change both pyramids.

If you have more than two projections loaded, you will be asked to choose which two pyramids should be shown before the pyramids appear.

7.1.6.7 Demographic dividend

The demographic dividend relates to the finding that populations that undergo rapid fertility decline experience an economic benefit when the changing age structure produces a situation where the percentage of the population of working age 15-64 is high relative to the dependent population, 0-14 and 65+. This allows for greater savings and investment, and can produce rapid economic growth if other conditions are helpful. When fertility is high, a large portion of the population is young, under 15. When fertility has been low for a while, a large portion of the population is older, over 65. During the transition from high to low fertility a situation emerges where the 15-64 age group is a larger portion of the total

population than at the beginning or end of the transition. The Spectrum outputs show the population 0-14, 15-64 and 65+ on a single graph, either by:

- **Percent, or**

- **Number**

7.1.6.8 Summary

Summary table. A summary table showing all indicators by year.

7.1.7 Methodology

7.1.7.1 Projecting the population by single ages

DemProj calculations are based on the standard cohort component projection modified to produce a single-year projection.

The inputs to the demographic projection are:

- Pop5(a,s): Population by 5 year age groups (a) and sex (s) in the base year
- TFR(t): Total fertility rate by year
- ASFD(a,t): Distribution of fertility by age by year
- SRB(t): Sex ratio at birth by year
- LEB(s,t): Life expectancy at birth with AIDS by sex and year
- Model life table
- Migration(a,s,t): Net in-migrants by age, sex and time

We assume that the base population is a mid-year estimate and that the rates (TFR, life expectancy and migration) are calendar year averages.

The first step is to split the base year population, which is in 5 year age groups, into single ages. This is accomplished by using the Beers procedure (Beers, 1945). This procedure uses a series of polynomial equations to divide the population in 5 year age groups into single year age groups while maintaining the population total and providing a smooth transition from one age to the next. This produces a base year population by single age: Pop(a,s,t).

The age distribution of migration is also specified in 5 year age groups. Migration is also split into single age groups using the Beers procedure.

Mortality is specified as life expectancy at birth by sex and a model life table. The life tables provide survival rates by single year of age for certain values of life expectancy, such as 20, 25, 30, 25, and so on. DemProj interpolates between these index values to find the age-specific survival rates for the exact life expectancy specified for each year.

Model life tables are provided in five year age groups. These are split into single age survival rates, S(a, a+1), using the life table indicators for nLx (the number of person-years lived between ages x and x+n by an initial cohort of 100,000 people) and lx (the number of survivors at age x out of an original cohort of 100,000 people).

1. Spop(0) = 1L0
2. Spop(1) = (l1 + l2) / 2
3. Spop(2) = (l2 + l3) / 2

4. Spop(3) = (I3 + I4) / 2
5. Spop(4) = (I4 + I5) / 2
6. Spop(5..80+) calculated by applying Beers procedure to nLx values
7. Calculate S(a,a+1) = Spop(a+1) / Spop(a)

The number of deaths from mid-year to mid-year is calculated as:
Deaths(a,s,t-1,1) = (Pop(a-1,s,t-1) + [migration(a-1,s,t-1)+migration(a-1,s,t))/2] * (1 − [S(a-1,a,t-1) + S(a-1,a,t))/2])

The number of deaths during the calendar year t is:
[Deaths(a,s,t-1) + Deaths(a,s,t)]/2

The population is projected by age and sex for ages 0 to 79 as:
Pop(a,s,t) = Pop(a-1,s,t-1) + [migration(a-1,s,t-1) + migration(a-1,s,t)]/2 − deaths(a,s,t-1,t)

The number of births from mid-year to mid-year is:
Births(t-1,1) = Σa=15,49 [Pop(a,female,t-1) + Pop(a,female,t)]/ 2 * [TFR(t-1) + TFR(t)] / 2 * [ASFD(a,t-1) + ASFD(a,t)] / 2

The number of births during the calendar year is:
[Births(s,t-1) + Births(s-t)]/2

The population of age 0 is:
Pop(0,s,t) = (Births(s,t-1) + Births(s,t))/2) * Spop(0)

Figure 11:   Fertility Distribution by TFR: UN Sub-Saharan Africa Pattern
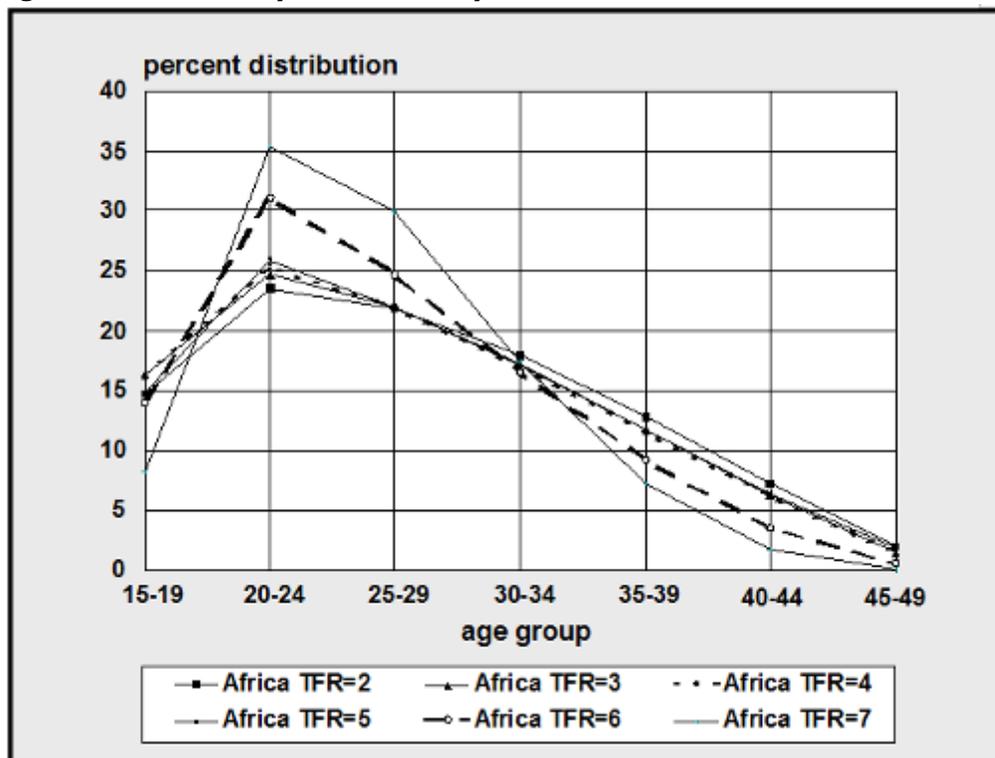
Figure 12: Fertility Distribution by TFR: UN Arab Pattern
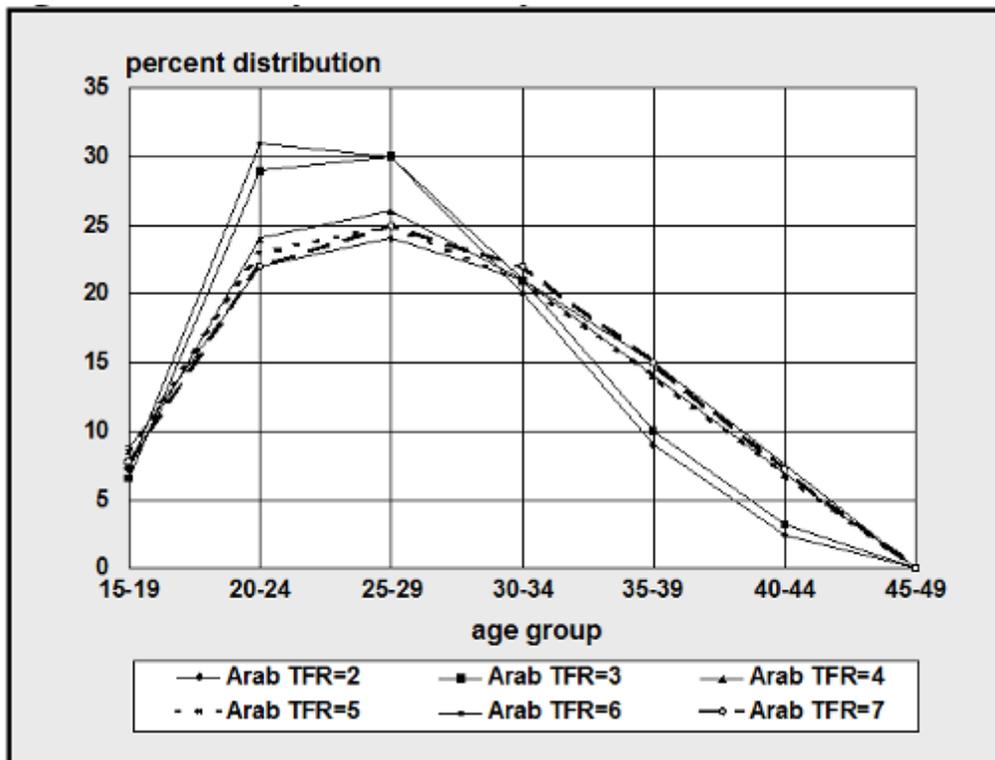
Figure 13: Fertility Distribution by TFR: UN Asia Pattern
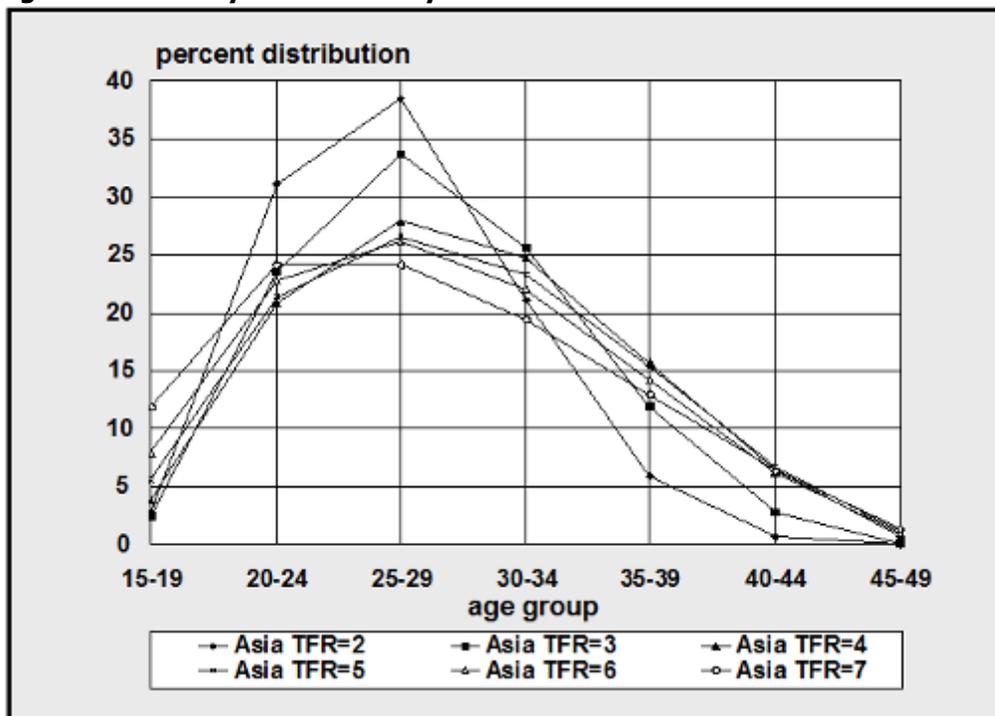
7.1.7.2   Urban and rural projections

The methodology of projecting urban and rural populations follows the United Nations method of growth rate difference.   In this method the size of the urban population is projected as follows:

$urban_t = urban_{t-1} \bullet (total_t + URGD \bullet rural_{t-1}) / total_{t-1}$

where:

$urban_t$	=	urban population at time t
$rural$	=	rural population
$total$	=	total population
$URGD$	=	urban rural growth rate difference.

This equation is actually a logistic function. The urbanization rate will slow after the percent of the population which is urban passes 50 percent.

The URGD is a combination of the difference in the urban and rural growth rates actually experienced in the most recent time period and the hypothetical difference calculated with the equation

$URGD' = 0.044 - 0.028 \bullet initial\ fraction\ urban.$

The rural population is calculated as the difference between the total population and the urban population.

This method is described fully in *Methods for Projections of Urban and Rural Population*, Manual VIII (United Nations, 1974).

The age distributions of the urban and rural populations are also calculated as logistic functions. This procedure makes use of the logit function. The logit of the percent urban is defined to be 0.5• ln (percent urban/[1 - percent urban]). In this approach the logit of the percent urban in each age group is assumed, as a first approximation, to increase as the logit of the total percent urban.

As an illustration, consider the steps in calculating the size of the 10-14 urban age group in 1985. First we calculate the increase in the logit of the percent of the total population that is urban:

$IUL = logit(\%\ urban\ in\ 1985) - logit(\%\ urban\ in\ 1980),$

where:

IUL = increase in urban logit.

Next, we assume that the logit of the percent of the 10-14 age group that is urban will increase by the same amount:

$logit(\%\ 10\text{-}14\ urban\ in\ 1985) = logit(\%\ 10\text{-}14\ urban\ in\ 1980) + IUL.$

The logit is then transformed back into a percentage and the size of the 10-14 urban age group is calculated:

$\%\ 10\text{-}14\ urban = (e^{2 \bullet logit[\%\ 10\text{-}14\ urban]}) / (1 + e^{2 \bullet logit[\%\ 10\text{-}14\ urban]})$

$urban\ pop\ 10\text{-}14 = total\ pop\ 10\text{-}14 \bullet (\%\ 10\text{-}14\ urban).$

These calculations are carried out for each age group. Then all the age groups are normalized to sum to the total urban population. The size of the rural age groups is simply the size of the total age group minus the size of the urban age group.

7.1.8 Glossary of terms

Many of the following terms were obtained from the Population Reference Bureau's *Population Handbook* (1989); others were adapted from the International Union for Scientific Study of Population's (IUSSP's) *Multilingual Demographic Dictionary* (Van de Walle and Henry, 1982).

Age-specific fertility rate (ASFR). The number of births in a year for a population of a given age and sex to the mid-year population of that same sex and age group.

Annual growth rate (GR). The rate at which the population is increasing or decreasing in a given year due to natural increase and net migration, expressed as a percentage of the base population.

ASCII (text) file. A file of text or data in a standardized, character format, which is transportable between software applications and operating systems.

Births. The total number of annual births.

Child-woman ratio. The number of children under the age of five per woman of childbearing age (15-49).

Coale-Demeny model life tables. Families of life tables derived from empirical life tables of Europe and other industrialized nations of the world. They are based primarily on data from the first half of the 20th century.

Cohort. A group of persons who experience certain events within a specified period of time, such as those who are born or who are married in the same year.

Cohort component projection. A projection made by subjecting all cohorts, on an annual or five-year basis, to mortality and migration assumptions, and applying fertility assumptions to women of reproductive age.

Crude birth rate (CBR). The number of live births per 1,000 population in a given year.

Crude death rate (CDR). The number of deaths per 1,000 population in a given year.

Deaths. The total number of annual deaths.

Dependency ratio. The ratio of the economically dependent part of the population (those aged 0-14 and 65 and over) to the productive part (those aged 15-64).

Dialogue box. A box permitting users to choose among a limited number of options. The box is accompanied by text elaborating upon those options.

Doubling time. The number of years it would take for the population to double its current size at the current annual rate of growth.

Fifth root. The fifth root of the number "n" is the number which, multiplied by itself five times, exactly equals "n." For example, the fifth root of 243 is 3 (3x3x3x3x3).

Gross migration. The total number of people who move to and depart from an area.

Gross reproduction rate (GRR). The average number of daughters that would be born to a woman (or a group of women) during her lifetime if she passed through all her childbearing years conforming to

the age-specific fertility rates of a given year. This is similar to the TFR except that it counts only daughters.

Infant mortality rate (IMR). The number of deaths to infants under one year of age per 1,000 live births.

Initial age distribution. The age-sex distribution at the beginning of a projection period.

Interpolation. Given two numbers that serve as boundary points, it is possible to estimate the values that lie at intervals between the two points. For example, if the total fertility rate for a country or region was actually measured only in 1980 and in 1995, by assuming even increments from year to year, it is possible to interpolate a TFR for each intervening year. (Spectrum uses a linear form of interpolation so that the difference between each annual value is the same. Other nonlinear forms of interpolation also are possible, but are not used in Spectrum.)

Life expectancy (e(0)). The average number of years a newborn can expect to live based on the mortality conditions at the time.

Life table. A table of values based on a series of related functions having to do with survivorship over intervals of time.

Logit. A function of the real number x (where x must be between 0 and 1), which is defined as logit(x) = $\ln(x/(1-x))$.

Mean age of childbearing. The average age of mothers at the time of birth.

Median age. The age that divides a population into two numerically equal groups.

Model. Computer system designed to demonstrate the probable effect of two or more variables that might be brought to bear on an outcome. Such models can reduce the effort required to manipulate these factors and present the results in an accessible format.

Model life table. A table of values based on a series of related functions having to do with survivorship over intervals of time.
Module. Synonym for "model".

Net migration. The number of people who move to an area minus those who move away.

Net reproduction rate (NRR). The average number of daughters that would be born to a woman (or a group of women) during her lifetime if she passed through all her childbearing years conforming to the age-specific fertility rates and age-specific mortality rates of a given year. This is similar to the GRR except that it includes the effect of mortality that would cause some women to die before completing their childbearing years.

Normalized. The transformation of a series of data points to a percent distribution summing to 100 percent.

Population aged 0-4. The portion of the population under age five. It is often of interest as it may be subject to high mortality, and consequently may require a large amount of health care relative to other age groups.

Population aged 5-14. The portion of the population which is generally considered to be of school age.

Population aged 15-64. The portion of the population which is generally considered to be of employment age.

Population aged 65+. The portion of the population which is generally considered to be of post-employment age.

Population projection. Computations depicting the future course of a population's size, its structure, and its interaction with dynamics such as fertility, mortality, and migration. The projection is constructed based on assumptions about the future course of those population dynamics.

Population pyramid. A graphic that portrays an age-sex distribution. It is so named because of its shape.

Pop-up menu. A menu from which users can select items or actions. Pop-up menus can appear anywhere on the screen.

Probability of dying (q_x). The probability that an individual (or group of individuals) having lived to exact age x will die before reaching exact age x+5.

Probability of survival (s_x). This term is the complement to the probability of dying. It refers to the probability that an individual who has reached exact age x will go on to live to exact age x+5

Pull-down menu. A menu opened by clicking on key words at the top edge of the screen. Pull-down menus allow users to select operations.

Quinquennial. Five-year age groups. The basis for most cohort component projections is five-year age groups over five-year intervals.

Radio button. These buttons emulate raised buttons on early radios, which were punched to select radio stations. The graphically portrayed raised "radio buttons" on interfaces permit users to select among at least three alternatives.

Rate of natural increase (RNI). The rate at which the population is increasing or decreasing in a given year due to the surplus or deficit of births over deaths, expressed as a percentage of the base population.

Semi-log graph. A graph of data points for which one axis is graduated logarithmically, and the other is not, almost always being arithmetic instead.
Sex ratio. The number of males per 100 females in a population.

Survival ratio. The proportion of the population of a particular age that survives to the next age in the next year.

Synthetic (hypothetical) cohort. A cross-section of the population whose various demographic experiences (such as mortality chances) are consolidated into summary indicators, as if to a true (birth) cohort.

Total fertility rate (TFR). The average number of children that would be born alive to a woman (or a group of women) during her lifetime if she were to pass through all her childbearing years conforming to the age-specific fertility rates of a given year.

Under five mortality rate (U5MR). The number of deaths to children under the age of five per 1,000 live births.

United Nations model fertility schedules. Five regional schedules prescribed by total fertility rate.

United Nations model life tables for developing countries. A set of families of life table schedules derived from empirical life tables from developing countries, based on data from the second half of the 20th century.

Vital statistics. Statistics on demographic events—births, deaths, marriages, and divorces—which are recorded through an event registration system.

7.1.9 Acronyms and abbreviations

AIDS	acquired immune deficiency syndrome
AIM	AIDS Impact Model
ASFR	age-specific fertility rate
CBR	crude birth rate
CDC	U.S. Centers for Disease Control and Prevention
CDR	crude death rate
CPS	Contraceptive Prevalence Surveys
DHS	Demographic and Health Surveys
e(0)	life expectancy
GDP	gross domestic product
GNP	gross national product
GR	annual growth rate
GRR	gross reproduction rate
HIV	human immunodeficiency virus
IMR	infant mortality rate
NRR	net reproduction rate
RAPID	Resources for the Awareness of Population Impacts on Development [project]
RNI	rate of natural increase
TFR	total fertility rate
U5MR	under-five mortality rate
UN	United Nations
USAID	United States Agency for International Development
WFS	World Fertility Surveys

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7.2 AIM
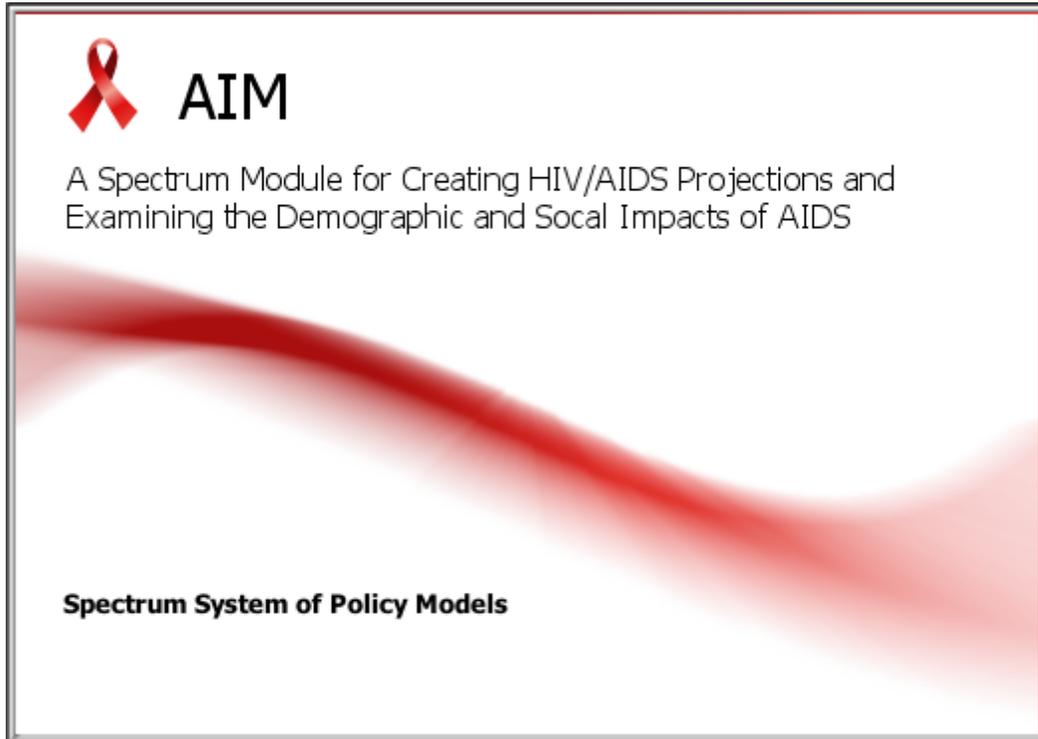
7.2.1 What is AIM?

The AIDS Impact Model, known as AIM, is a computer program for projecting the impact of the HIV/AIDS epidemic. It can be used to estimate the number of people infected with HIV, the number of new infections, the need for treatment, the need for programs to prevent mother-to-child transmission and many other indicators of interest. These projections then can be used in graphic policy presentations intended to enhance knowledge of AIDS among policymakers and to build support for effective prevention and care.

The Futures Group, in collaboration with Family Health International, prepared the first version of AIM in 1991 under the AIDS Technical Support (AIDSTECH) and AIDS Control and Prevention (AIDSCAP) projects. The program has been revised a number of times since then in collaboration with the UNAIDS Reference Group on Estimates, Models and Projections. Since 2009 it has been maintained and updated by Avenir Health with support from the Bill & Melinda Gates Foundation and UNAIDS.

AIM (and the entire Spectrum system of models) is designed to produce information useful for policy formulation and dialogue within a framework of computer programs that are easy to use. The focus is on generating information useful for policy and planning purposes rather than on carrying out detailed research into the underlying processes involved. For this reason, the program is designed to be used by program planners and policy analysts. AIM uses data that are readily available and requires little technical expertise beyond what can be acquired through literature review and use of this manual.

The major inputs and outputs of AIM are shown in Figure 1. Demographic projections are based on user inputs or projections prepared by the United National Population Division. The projections start with an estimate and projection of adult incidence, which is combined with information on the age and sex distribution of incidence and progression to death to estimate the number of new adult infections by age and sex. New infant infections are estimated from prevalence among pregnant women and the rate of

mother-to-child transmission, which is dependent on infant feeding practices and the coverage of prophylaxis with antiretrovirals (ARVs). New infections progress over time to lower CD4 counts and are subject to AIDS-related mortality. Those who receive first and or second line ART experience extended survival. People at any stage are also subject to non-AIDS mortality at the same rates as those who are not infected. Adult deaths result in orphans.

Figure 1. Structure of AIM module
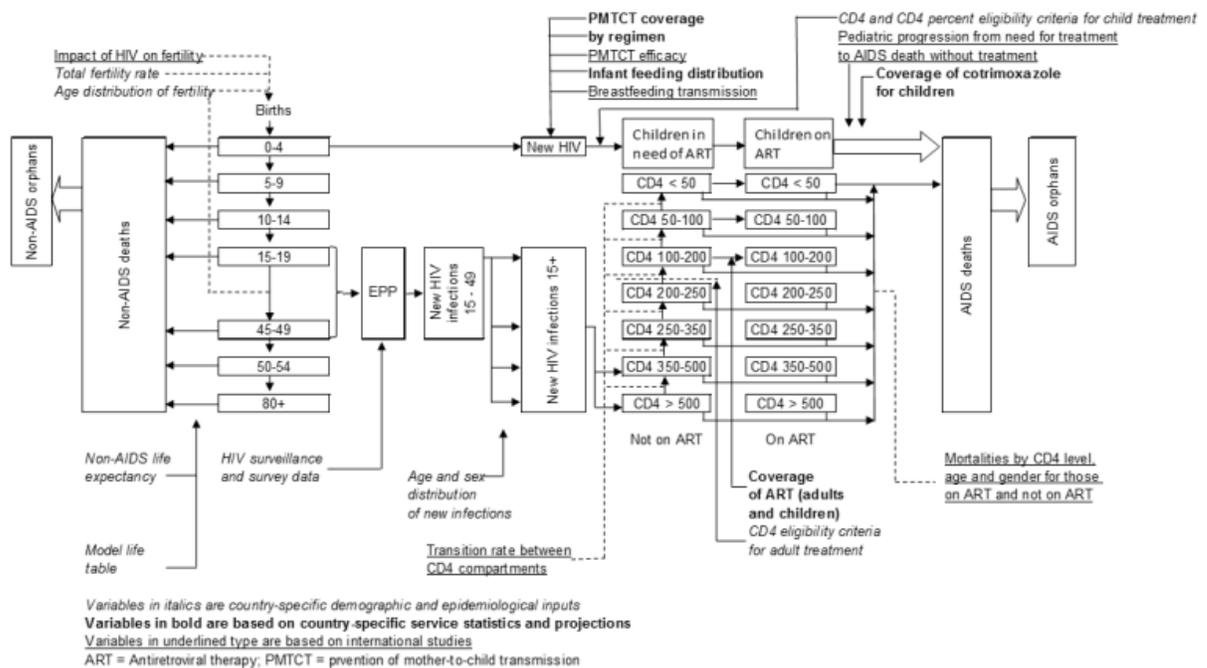
7.2.2 Overview of estimation and projection tools

7.2.2.1 Introduction

7.2.2.1.1 Purpose of estimation and projection tools

A well planned response to the HIV epidemic requires specific information on the projection of the disease over time. This projection needs to be based on previous measures of prevalence in the population as well as data from programs on their effectiveness and coverage.

UNAIDS and partners have developed software to assist countries to map their HIV epidemic and determine the consequences of the epidemic. Consequences such as number of people living with HIV, number of new infections, number of pregnant women infected with HIV, mortality due to AIDS and treatment needs are all provided from these programs. From these data countries can estimate their potential service and pharmaceutical needs, can plan for health care service requirements, and can get a general understanding of the overall impact of their response.

7.2.2.1.2 Reference group on estimates, modeling and projections

The methods and data in AIM are informed by the UNAIDS Reference Group on Estimates, Modeling and Projections. This is a group of experts from multiple disciplines and institutions. These experts include epidemiologists, demographers, clinicians, modelers, as well as implementers from countries with different types of epidemics. The Reference Group meets several times a year and the software is updated every year. For more information on the Reference Group go to www.epidem.org.

7.2.2.1.3 Processes to create estimates and projections

Every two years UNAIDS and partners hold regional trainings to explain new features and review the computer programs with country epidemiologists. Country teams usually consist of individuals from the national programs who have a strong capacity for epidemiology and modeling and may include development partners who work on HIV surveillance in the country. These teams work in groups at the trainings to update the estimates with the country's most recent surveillance and program data. As a result, the country is able to use the software to estimate and project the future consequences of the epidemic for the country.

After the regional trainings, countries are expected to refine and share the outcomes with other interested parties in the country. Once the models are completed the country provides the final results to UNAIDS headquarters to inform the regional and global estimates of HIV. Countries are encouraged to create estimates and projections reports for their individual countries and to communicate the results to a broad spectrum of potential users of the data.

7.2.2.1.4 Different types of epidemics

There are significant variations in HIV epidemics around the world. Different epidemics require different types of surveillance and modeling techniques. UNAIDS uses the classifications, generalized and concentrated to differentiate types of epidemics.

The type of epidemic also determines which computer programs are necessary for modeling the epidemic and how to use those programs.

7.2.2.1.4.1 Generalized epidemic

- HIV is firmly established in the general population.

- Although sub-populations with higher risk may continue to contribute disproportionately to the spread of HIV, sexual networking in the general population is sufficient to sustain an epidemic independent of subpopulations at higher risk for infection.

- Numerical proxy: HIV prevalence is consistently over 1% in pregnant women.

- In generalized epidemics, the prevalence among pregnant women is usually a fairly good indicator of prevalence in the total adult population. Prevalence is usually higher in urban areas than in rural areas. Therefore, most countries with generalized epidemics can be modeled using two distinct sub-populations (an urban population and a rural population).

7.2.2.1.4.2 Concentrated epidemic

- HIV has spread rapidly in at least one defined sub-population, but is not well-established in the general population. Most often more than one subpopulation with higher risk is affected.

- This epidemic state usually suggests active networks of risk exist within and between the sub-populations.

- Numerical proxy: HIV prevalence is consistently over 5% in at least one defined subpopulation. HIV prevalence is below 1% in pregnant women in urban areas.

- In concentrated and low-level (low prevalence) epidemics HIV infection is primarily concentrated in certain sub-populations. Therefore, countries with concentrated epidemics are usually modeled by combining epidemic curves for several subpopulations.

7.2.2.2   Data required for estimation and projection

The quality and accuracy of the estimates depend on the quality and accuracy of the data used for the models. If very little information is available on HIV prevalence in the country the model will rely heavily on assumptions used in the model. On the other hand, countries which have conducted routine surveillance and covered groups which are most important to the epidemic will be able to inform the models with substantial data resulting in high quality estimates and projections.

In generalized epidemics, data from sentinel surveillance sites at antenatal clinics (ANC) are required. Data from population based surveys and routine testing of pregnant women are also very useful for informing the models. The models are able to utilize data to distinguish urban and rural epidemics or different regional epidemics.

In concentrated epidemics more specific information is required about the populations that are at increased risk to HIV. The software separates the epidemic into sub-populations. However the user must have information on each of the sub-populations that are used in the epidemic structure. For example if a country specifies female sex workers and injecting drug users as important risk categories they will be required to enter data for those two sub-populations and the remaining general population. Data required for each sub-population include estimates of the population size, HIV surveillance data from the group over time.

For all epidemic types, the software requires additional program data on the number of men, women and children on ART, the number of women receiving ARVs for prophylaxis (PMTCT) and other demographic and epidemiological information to determine the impact of HIV.

If there are no recent data on HIV prevalence available in the country then no estimate should be created.

7.2.2.3   Computer programs for estimation and projection

Several methods are available for estimating incidence and prevalence trends from surveillance, survey and program data.

The **Estimation and Projection Package (EPP)** is used by countries that have good surveillance data. In countries with generalized epidemics EPP can also use data from national household surveys and program data from antenatal clinics. EPP finds incidence curves that provide the best fit to HIV prevalence data. Several different models are available within EPP. The R-Hybrid model is recommended for most applications. EPP Classic may be used in settings with very sparse data. In some setting the R-Spline model or the R-Trend model may be preferred. For more information on these options, consult the UNAIDS Quick Start Guide.

The **Case Surveillance and Vital Registration (CSAVR)** model is used by countries that have good data on mortality and new case reports. It searches for incidence curves that provide the best fit to data on the numbers of AIDS deaths and new diagnoses.

The **AIDS Epidemic Model (AEM)** is used by a number of countries in Asia to fit prevalence and incidence to data on key population prevalence.

The **ECDC Model** is used by many countries in Europe to fit incidence curves to new case reports.

7.2.3   AIM input editors

AIM requires data describing the characteristics of the HIV/AIDS epidemic and the response to it. Some of these inputs require national data while others rely on recommended values based on a review of scientific studies. All AIM projections require a demographic projection. There are six categories of HIV-related inputs:

- Program statistics (country specific)
  - Number of women provided with PMTCT services by type of regimen
  - Number or percent of adult men and women receiving anti-retroviral therapy (ART)
  - Number or percent of children receiving ART and/or co-trimoxazole

- Eligibility for treatment (country specific)
  - Eligibility criteria for adults
  - Eligibility criteria for children

- Advanced options (usually based on global or regional default patterns)
  - Pediatric transition parameters
    - Annual rate of progression to next lower CD4 category
    - Distribution of new infections by CD4 percent category
    - HIV mortality without ART
    - HIV mortality with ART
    - Distribution of new ART patients by age
    - Effectiveness o co-trimoxazole in reducing mortality for HIV+ children
  - Adult transition parameters
    - The amount of time spent in each CD4 cell count category
    - The distribution of new adult HIV infections by CD4 cell count
    - Adult HIV mortality rate without ART by CD4 cell count, sex and age
    - Adult HIV mortality rate while on ART by CD4 cell count when initiating ART, sex, and age
    - Ratio of fertility of HIV+ to HIV- women by age and CD4 count
  - Mother-to-child transmission probabilities
  - DALY weights
  - Allocation method for new ART patients
  - Epidemic type for orphan calculations

- Adult HIV incidence (generated using EPP, CSAVR or AEM)

- Sex/Age pattern (Based on either country-specific estimates or global patterns)
  - The ratio of new adult female infections to new adult male infections by year
  - The incidence rate ratio by age, sex and year

Each of these inputs is discussed in detail in the following sections.

7.2.3.1   Demographic projection

AIM requires that a demographic projection first be prepared using DemProj, another model in the Spectrum system. Model users should keep three key points in mind when preparing a DemProj projection for use with AIM:

1. DemProj contains a feature called EasyProj that automatically provides the necessary demographic data once you have set the first and last years of the projection and selected the country.

2. The first year of the projection should be before the starting year of the HIV/AIDS epidemic. It is usually best to start the projection in 1970. It is possible to start the projection in a year after the beginning of the AIDS epidemic but that should not be done if you want to estimate the incidence trend from surveillance, survey and program data.

3. The life expectancy assumption entered into DemProj should be the life expectancy in the absence of AIDS. AIM will calculate the number of AIDS deaths and determine a new life expectancy that incorporates the impact of AIDS. It is necessary to use this two-step process because model life tables (for specifying the age distribution of mortality) do not contain patterns of mortality that reflect the excess deaths caused by AIDS.

Spectrum contains a data base of demographic data for most countries. These estimates and projections are from the United Nations Population Division's World Population Prospects, 2022 Revision. You can make sure you are using the latest data by clicking the Manager icon, then click Default Data, then select 'Load data' next to DemProj, then click OK. This will update your projection to the latest World Population Prospects data. You should not do this if you have modified your demographic data or if you are using a sub-national projection, since this action will replace your existing data.

7.2.3.1.1 Adjusting the population size to match current estimates

If you use EasyProj for your demographic projection it is possible that the population size may not match the most recent census estimate. The United Nations Population Division bases their estimates and projections on the latest available demographic data for each country. However, a typical application of Spectrum starts the projection in 1970 or 1980 and projects forward to today. Small variations in any of the inputs can affect the population size 25 to 30 years later. Perhaps the most important difference is that the UN Population Division estimates may use a different HIV prevalence trend than the one you are using in Spectrum. In that case, the population projected by Spectrum may not match the UN Population Division estimate or the latest census estimate. Variations in the age distribution of mortality or migration can also cause small difference in the population size today.

If this problem occurs you can get a better match to the census population by adjusting some of the inputs to the demographic projection. Changes to the fertility rate, life expectancy, the model life table chosen and the migration inputs can help to fine tune the projection. Of course, changes to the HIV prevalence curve could also make a difference.

One quick way to get a good match to today's population estimate is to adjust the starting population. One of the demographic inputs is the population by age and sex in the base year. These inputs might need to be adjusted upwards or downwards to modify the current year population projection. This can be done easily by using the "Multiply" button in the editor for the base population to multiply all the inputs by a constant factor. That factor could be the ratio of the actual current year population to the projected population. After making this adjustment the new population projection should match the current estimate better. This approach is only a quick fix. It is always desirable to examine the fertility, mortality and migration assumptions as well as the starting population to reconcile them with national statistics. Most countries have national population projections that can be used as a source of information for the Spectrum projection.

You do not need to use EasyProj to generate the demographic projection. You can input your own data. However, this should be done with caution. Raw census data on the number of people by age and sex should be adjusted to account for age mis-reporting and undercounts before they can be used in

Spectrum. The projection requires past and future trends in the total fertility rate and non-AIDS life expectancy. Information on the non-AIDS life is not likely to be readily available. Thus it is often better to start with EasyProj and then adjust any inputs as necessary than to build your own projection from the start.

7.2.3.2 Program statistics

7.2.3.2.1 Prevention of mother-to-child transmission of HIV (PMTCT)

The mother-to-child transmission rate is the percentage of babies born to HIV-infected mothers who become infected. The rate depends on a number of factors including the stage of infection of the mother, the duration of breastfeeding and the use of ARV prophylaxis to prevent the transmission.

The input editor of PMTCT is accessed by selecting *Modules -> AIM -> Program statistics -> PMTCT*

There are three inputs associated with PMTCT: the number of women receiving PMTCT services by ARV regimen, the pattern of breastfeeding and, for special cases, abortion associated with HIV-infection.

ARV regimen

- Prenatal prophylaxis. Here you should enter the number of women receiving PMTCT services by regimen and year. It is recommended that you enter the number of women for all historical years. For future years you may enter either numbers or percentage of women in need. All entries for a single year must be either numbers or percentages. You cannot mix them in the same year.
- Percent retained at delivery. This is the percentage of women who are on ART during pregnancy who remain on ART at the time of delivery. The default value is 85%.
- Post-natal prophylaxis. In years when Option A or Option B were used, you should enter the number or percentage of women who started those options during the prenatal period who remain on them at the start of breastfeeding.
- Monthly drop-out of post-natal prophylaxis. The percentage of women on Option A, Option B or Option B+ who drop-out of prophylaxis each month.

Breastfeeding

Here you enter data on the percentage of children who are not breastfeeding by the age of the child in months. Default data are drawn from DHS surveys. These data refer to all women including HIV+ and HIV-. If you have data from program sources on breastfeeding patterns among HIV+ women in the PMTCT program you can enter those data separately. If breastfeeding patterns have changed over time, you can select the 'Data for all years' option and enter patterns for each year. You can also click on the 'Read survey data' button and import the breastfeeding information from the most recent DHS if it is available.

Abortion

If some HIV-positive pregnant women choose an abortion you can enter the number of abortions here.

7.2.3.2.1.1 Women receiving PMTCT services

If the editor for women receiving PMTCT services is not shown when you enter Program Statistics its can be accessed by clicking on the 'ARV regimen' button.

For past years the entries should generally be the number of women receiving each type of prophylaxis. For future years the entries may be either projections of the number of women expected to receive services or the coverage (the percentage of HIV+ pregnant women receiving services). The types of prophylaxis are:

- No prophylaxis

- Single dose nevirapine: single dose of nevirapine (NVP) given to the mother at the time of delivery and the child shortly after birth.

- Dual ARV: Daily zidovudine (ZDV) for the pregnant woman from the 28th week of gestation, plus single-dose NVP during labor and 7 days of ZDV plus lamivudine (3TC) postpartum.

- Option A: Twice daily ZDV starting from the 14th week of gestation, single-dose nevirapine at the onset of labor, twice daily ZDV+3TC for seven days post-partum plus daily NVP for the infant until one week after the cessation of breastfeeding.

- Option B: Triple ARV drugs for the pregnant woman starting from the 14th week of gestation until delivery or one week after the cessation of breastfeeding.

- Option B+: ART started before current pregnancy: Pregnant woman started on life-long triple ART before the current pregnancy.

- Option B+: ART started during current pregnancy >4 weeks before delivery: Pregnant women who start on triple life-long ART during the current pregnancy more than 4 weeks before delivery.

- Option B+: ART started before current pregnancy <4 weeks before delivery: Pregnant women who start on triple life-long ART during the current pregnancy more than 4 weeks before delivery. If women start on ART late they will have less viral suppression at the time of delivery and transmission rates are likely to be higher. If no information is available this option can be set to 0, or an estimate can be made using data from national surveys on the proportion of pregnant women that show up for their first antenatal visit less than four weeks before delivery.

WHO currently recommends that all HIV+ pregnant women receive ART for their own health and to reduce transmission to their babies. The other regimens are still included in AIM in order to capture past program effects and because not all countries have adopted the new guidelines.

It is usually best to enter numbers of women by regimen for past years and coverage (percentage of HIV+ pregnant women receiving PMTCT) for future years. It can be difficult to estimate the numbers for future years especially if the need changes significantly. A future coverage goals can be entered and the program will calculate the number of women needed services to achieve that goal.

Retention. Not all women who start ART will continue until delivery. The rows 'Percent already on ART retained at delivery' and 'Percent starting ART retained at delivery' refer to the percentage of women on ART (Option B+) who remain on ART at the time of delivery. By default these percentages are set to 85 percent for those already on ART before the current pregnancy and 80 percent for those who start ART during the current pregnancy.

Drop-out. Women on Option A, Option B or ART may drop-out during breastfeeding. The input is the percent who discontinue prophylaxis each month. For women on ART there are two drop out rates for the period 0-12 months and greater than 12 months. A review of available studies indicated that the default values for drop-out should be 1.2 percent per month for 0-12 months and 0.7 percent per month after 12 months of breastfeeding.

Reallocation. In the case of sub-national files there may be situations where women come from outside the province or region to receive PMTCT services. When that happens PMTCT coverage will be over-estimated since the numerator (the number of women receiving services in the province) does not match the denominator (HIV+ pregnant women in the province). The reverse happens when some women within the province seek services elsewhere. In that case, PMTCT coverage will be under-estimated and the mother-to-child transmission rate will be too high. To address this problem, you can specify the number of women receiving services in a regional other than their region of residence. Positive numbers indicate that women who are receiving services outside this region. Negative numbers indicate women receiving services from another region.

Calculated mothers needing PMTCT. The final row will show the estimated number of women in need of PMTCT services. The is based on the last time the projection was calculated, so may be out of date if you have made other changes.

7.2.3.2.1.2 Breastfeeding patterns

The editor for breastfeeding patterns is accessed by clicking on the 'Breastfeeding' button.

This editor accepts information on the typical breastfeeding pattern of all women and women enrolled in the PMTCT program. By default they are the same, but the pattern for women enrolled in the program can be changed if information is available.

The data are entered as the percentage of women no longer breastfeeding by the age of the child in two month intervals. These data usually come from a national survey, such as a Demographic and Health Survey. Default data are supplied for most countries based on the latest survey.

Data may be entered for the current year or for all years (chosen by selecting the appropriate radio button at the top of the screen). If data are entered for the current year only, then those data will be used for all years in the calculations. If program recommendations regarding breastfeeding by HIV+ mothers have changed over time then these changing patterns can be entered by selected the 'Data for all years' option.

7.2.3.2.1.3 Abortion

A third editor in this section allows the specification of the percent or number of pregnancies among HIV+ women that are terminated by abortion. Most countries do not include abortion as an option in their PMTCT programs. In those cases this editor can be ignored.

7.2.3.2.1.4 Transmission probability

The probability of transmission of HIV from mother to child depends on the stage of infection of the mother, the duration of breastfeeding and the prophylactic regimen. The table below summarizes the default probabilities currently used in AIM. These are based on expert review of available studies. It is not recommended to change these rates.

Table . Probability of Mother-to-Child Transmission (Percent)

Regimen	Perinatal	Breastfeeding (Monthly Probability)	
No prophylaxis			
Existing infections			

CD4<200	37.00	0.89	
CD4 200-350	27.00	0.81	
CD4>350	15.00		0.51
Incident infections	18.20	26.90 (one time event)	26.90 (one time event)
Single dose nevirapine	7.5	0.99	0.40
WHO 2006 dual ARV regimen	2.2	0.18	0.18
Option A	4.1		0.20
Option B	1.9		0.13
Option B+			
Started before pregnancy	0.26	0.02	
Started during pregnancy more than 4 weeks before delivery	1.40	0.11	
Started during pregnancy less than 4 weeks before delivery	8.2	0.2	

Source: Mofenson, L, Updating PMTCT Transmission Probabilities for Use in the Spectrum Model, Report to UNAIDS, October 24, 2018.

7.2.3.2.2 ANC testing

Information on prevalence among pregnant women is used in model fitting. Thus it is important that these data be accurate. The ANC testing editor collects information that can be used to assess the quality of the ANC testing information.

The rows in this editor are:

-**# births**: This is the number of births calculated by the DemProj module. You cannot edit this number, it is shown for reference only because it is used as the basis for the PMTCT calculations.
-**Program reported births:** You should enter the number of births reported by health facilities. Usually this number should be less than the number of births estimated by DemProj and displayed in the first row since some births may happen outside facilities and not get reported. If this figure is much higher or lower the the estimates number of births displayed in the first row, then there could be problems with the PMTCT calculations.
-**# first ANC visits**: The number women making a first ANC visit during the year. This should be similar to program reported births if ANC attendance is nearly universal. It may be less if the percentage of births with skilled attendance is less than ANC attendance.

-**# receiving at least one HIV test:** The number of women receiving at least one HIV test
-**# testing positive at their first HIV test**: The number of women who tested HIV-positive at the first test.
-**# re-tested**: The number of women who re-tested during the pregnancy
-**# positive at re-test:** The number of women who tested HIV-positive at the re-test
-**# known to be HIV+ at first ANC visit (including on ART)**: The number of women known to be HIV-positive at the first ANC visit, including those already on ART, and, therefore, not tested
-**# known to be HIV- at first ANC visit**: The number of women known to be HIV-negative at the first visit and, therefore, not tested
The next three tows are automatically entered from the data previously entered in the 'PMTCT' editor. They cannot be changed here.
-**# started ART before current pregnancy**: The number of women already on ART at time of their first ANC visit.
-**# started ART during current pregnancy >4 weeks before delivery**: The number of women who started ART during the current pregnancy and started more than 4 weeks before delivery.
-**# started ART during current pregnancy <4 weeks before delivery**: The number of women who started ART during the current pregnancy but started late, less than 4 weeks before delivery.
-**% HIV+ (census-level ANC-RT):** The percent of pregnant women who are HIV+ as reported based on program data from all ANC sites. This information is read from the EPP Surveillance editor if available. It cannot be change here. It can be compared the implied prevalence from the data entered on this page which is shown in the last row.
-**% HIV+ (calculated)**: This is the HIV prevalence among pregnant women implied by the program data entered on this page. It is calculated as the number testing positive at their first HIV test + the number known positive at first ANC visit divided by the number receiving at lead one HIV test plus the number known positive.

Once this information is entered for as many years for which data are available, the screen will display two charts:

The left hand chart shows the ANC testing cascade for all women. It includes bars for the number of births as estimated by the model (blue), the number of births recorded by the program (gold), the number of first ANC visits (light blue) and the number of women who received at least one HIV test (pink). We expect to see the highest number for births, followed by the number of ANC visits and then the number tested. If the data do not follow this pattern, it may indicate a problem.

The right hand chart shows trends in PMTCT. There are bars for the number testing HIV-positive at the first visit (orange), the number of known positives (red) , the number on ART before the pregnancy (dark green), the number receiving prophylaxis during pregnancy and starting more than 4 weeks before delivery (light green) and the number starting prophylaxis less than four weeks before delivery (pale green). This chart allows you to see how the distribution of pregnant women has changed over time and spot any inconsistencies in the inputs.

7.2.3.2.3 Adult ART

There are three options for specifying coverage of ART for adults. The options are specified using the radio button at the top of the editor. In most cases the first option 'Number or percent' is preferred.

1. **Number or percent**. With this option you enter the number of men and women receiving ART in each year. Alternatively you can enter the percentage of adults living with HIV (adult PLHIV) who receive ART. The best approach is to enter the number on ART for past years and use a coverage rate (percentage) for the future. The numbers entered here should refer to the number of adults currently using ART on December 31 of each year. This is not the same as the number

newly initiating ART. These figures are routinely reported by national programs to WHO and UNAIDS and are published in annual treatment progress reports.

The editor screen will display the estimated number of adult PLHIV. Note that this is based on the last time the projection was made. It will not include the effects of any recent changes in inputs that you have made if they have not been re-projected (which happens automatically whenever you display an output indicator).

Percent lost to follow-up each year. This is the percentage of patients on ART the previous year who drop out of ART each year. This figure should represent actual drop-outs. It should not include those who die while on ART (mortality is calculated elsewhere) and it should not include those who switch facilities but continue on ART.

Number initiating ART. If you also have information on the number initiating ART each year you can enter them here. These data will not affect the calculations but can be used to validate the calculated number initiating. If your data do not match the calculations then there is an inconsistency between the number on ART, the lost to follow-up rate and the number initiating each year.

2. **CD4 by percent**. As a second option you can specify the coverage of ART by CD4 cell count category. If you select this option then for each year you enter ART coverage for each CD4 count category. Typically you might have high coverage at low CD4 counts and lower coverage at higher counts. You can also specify coverage for population groups that are considered eligible for treatment regardless of CD4 count.

3. **CD4 by number**. This is the same as 'CD4 by percent' except that the number of people on ART is entered for each category instead of the coverage.

If you choose the first option 'Number or percent' you will have to other options.

-**Read from ADR**: If you click this button you will be able to read the program data directly from a file in your AIDS Data Repository (ADR) folder. This will be a csv file also used as input to Naomi. The file should have 8 columns: area_id, area_name, sex, age, age_group, calendar_quarter, art_current, art_new, vl_tested_12mos, vl_suppressed_12mos. Using this feature will ensure that the same data are used for both purposes. This feature is only available to those who have access to an ADR folder, usually members of a national HIV estimates team.

-**Adjust program data for under/over count due to data quality review**: If you have conducted a data quality review that indicates that the data in your HMIS may be over or under-counted you can use this feature to adjust them. This allows you to still use the data as they exist in the HMIS but specify a correction to make them as accurate as possible. Check the box 'Enable adjustment' then click the button 'Enter adjustments'. You will see an editor where you can enter annual scaling factors for men and for women. This adjustment will be applied when the program next calculates. It will only be applied when the box 'Enable adjustment' is checked.

On this page there is a 'Plot values' button. If you click this button you will see a line chart showing the number on ART by year. Reviewing this chart can help to spot any input errors.

7.2.3.2.4 Child treatment

Treatment for children includes both ART and cotrimoxazole. As with the other editors you can enter either numbers of children receiving treatment or coverage (percentage of those eligible) as of December 31 of each year.

You can enter a single figure for all children (aged 0-14) on ART or enter the number by five year age group (0-4, 5-9, 10-14) if you have those data.

The percent lost to follow-up is the percentage of children on ART who are disengaged from treatment each year. Note that this should be true disengagement. It should not include those who have died or switched clinics.

The need for cotrimoxazole is based on WHO guidelines which recommend cotrimoxazole for all HIV+ children and all HIV-exposed infants until HIV infection can be excluded after breastfeeding cessation.

The need for ART is all children living with HIV.

7.2.3.2.5 Knowledge of status

Information about the percentage of the HIV-positive population that knows its status may come from five sources:

- **Case reports:** If good information is available from case reports of new diagnoses and AIDS deaths then the percentage of the population who know their status can be estimated from the cumulative case reports of new diagnoses and the cumulative reported number of AIDS deaths. These figures should be cumulative since the beginning of case reports.

- **Shiny 90**. This is a program that estimates current knowledge of status based on historical information from surveys and program testing data. It can be accessed by clicking on the button 'Launch Shiny90 in browser' . Once you have finished making a Shiny90 projection and returned to Spectrum you can read the results into this editor by clicking the button 'Load data'.

- **CSAVR**: CSAVR is a tool in Spectrum to fit an incidence trend. If you use that tool you can use the output from CSAVR on knowledge of status in this editor.

- **ECDC.** ECDC is another program, like CSAVR, that determines and incidence trend by fitting to case reports. It also produces estimates of knowledge of status that can be used here.

- **Direct input**. If you cannot use any of the other methods, you can input knowledge of status directly.

7.2.3.2.6 ART by age

If you have information on the number of people on ART by age, you can enter them here. You can either use 5-year age groups or the large age groups used by the Global AIDS Monitoring (GAM) system (0-4, 5-9, 10-14, 15-19, 20-24, 25-49, 50+). These data will only be used for validation by comparing against the modeled estimates. This is done under the Validation menu in the ART section.

7.2.3.2.7 Viral suppression

Viral suppression refers to the percentage of people living with HIV who are virally suppressed. There are two possible sources of information:

- **Laboratory, program or case surveillance**: If data are available from the Health Information Management System (HMIS) they can be used here. Enter the number of people tested among those on ART and the number with suppressed viral load, less than 1000 copies/ml. Fill in those years for which you have data and leave the other years blank.

- **Surveys**: If you have information on viral suppression from a recent survey, such as a Population-based Health Impact Assessment (PHIA), enter those data here for the appropriate age groups in the year of the survey. Indicate the year of the survey in the drop-down box.

You should enter data for both the number of people tested and the number tested who were found to be virally suppressed. At the top of the display you can see the number of people on ART. This information is used as a check only. You cannot edit it here. That is done in the Adult ART and Child ART editors.

The program will display the calculated testing ratio, the ratio of the number of people tested to the total number on ART.

Viral suppression threshold. You should also enter the viral suppression threshold used to determine if a person is virally suppressed. By default this is 1000 copies/ml. However, if your program uses a difference threshold (for example: 600, 400, 200, 50), enter it here for the appropriate years. The final row will display the estimated percentage suppressed at the 1000 threshold using the following equation: $VS\_1000 = y^{\{[(6-\log(1000))/(6-\log(th))]^{1.5}\}}$, where y is the percent virally suppressed and th is the viral suppression threshold.

7.2.3.3 Eligibility for treatment

7.2.3.3.1 Adults

There are two components to defining eligibility for adults: CD4 count and special populations.

1. **CD4 count**. For each year in the analysis you can specify the CD4 count threshold for treatment. That is the CD4 count below which all HIV+ adults are eligible for treatment. According to WHO guidelines this was 200 cells/μl until 2010 then changed to 350 cells/μl and changed again in 2013 to 500 cells/μl[1]. In 2015 the recommendations were revised to include all people living with HIV regardless of CD4 count. Criteria for national programs may differ. When a new projection is created it will have the WHO criteria listed as a default. Those criteria can be changed to match national guidelines. To indicate that all people living with HIV are eligible for treatment (2015 guidelines) enter 999.

2. **Populations eligible for treatment regardless of CD4 count**. Some populations are considered eligible for treatment regardless of CD4 count. In the 2013 WHO guidelines those population include HIV+ pregnant women, those co-infected with HIV and TB or severe HBV disease, and discordant couples. Some programs may also include other populations, such as sex workers, men who have sex with men, and people who inject drugs. Any populations eligible regardless of CD4 count are indicated by checking the box in the 'Eligible' column. You should also specify the year that this population became eligible and the percentage of the adult HIV+ population that is in the special population. The model will calculate this value for pregnant women. For other populations there will be default values presented, which you can accept or change if you have better information. If you include the 'Other' population group then you must specify the percentage of HIV+ adults in this group.

7.2.3.3.2 Children

For children there are three components to defining eligibility: age, CD4 count and CD4 percent.

1. **Age**. In many programs all HIV+ children below a certain age are considered eligible for ART. In 2007 WHO recommended that all HIV+ children below the age of 12 months be eligible for treatment. That guideline was raised to 24 months in 2010 and 60 months in 2013 and then in 2015 to all children regardless of age (180 months).

2. **CD4 count**. Eligibility for children may also depend on CD4 count. If the child is already eligible because of age then the CD4 level does not matter. If the child is above the age of eligibility then eligibility may be determined by CD4 count. In past guidelines the CD4 level for eligibility has varied by age.

3. **CD4 percent**. For very young children eligibility is often based on CD4 percent rather than CD4 count. Eligibility thresholds by CD4 percent can be entered here.

Note that a child is considered eligible for ART if it meets any of the three criteria: age, CD4 count or CD4 percent. Table 2 shows the eligibility criteria recommended by WHO over time.

Table 2. Criteria for eligibility for ART among children over time

	2000-2006	2007-2009	2010-2012	2013-2014	2015
Age below which all HIV+ children should receive treatment (months)	0	12	24	60	180
CD4 count threshold for eligibility					
Age <11 months	1,500	NA	NA	NA	NA
Age 12-35 months	750	750	750	NA	NA
Age 35-59 months	350	350	750	NA	NA
Age >= 5 years	200	200	350	500	NA
CD4 percent threshold for eligibility					
Age < 11 months	25	NA	NA	NA	NA

Age 12-35	25	25	25	NA	NA
Age 35-59	25	25	25	NA	NA
Age >= 5 years	15	15	15	15	NA

7.2.3.4   Advanced options

7.2.3.4.1 Pediatric transition parameters

Progression rates. The 'Progression rates' tab show the annual rates of progression from one CD4 category to the next lower category. The default values have been determined to match survival curves developed from an analysis of child survival studies by Marston and Becquet (Marston M, Becquet R. Net survival of children HIV-infected perinatally and through breastfeeding: a pooled analysis of individual data from resource-constrained settings, December 2010.) This page also includes the distribution of new child infections by CD4 percent.

HIV mortality without ART. This tab shows the annual mortality rates for HIV-infected children who are not on ART by CD4 category age and time of infection. These rates have been derived to fit the survival curves from Marston and Becquet.

HIV mortality with ART. The patterns of AIDS-related mortality of children on ART are derived from the IeDEA Consortium (Mahy et al. 2017 Improving estimates of children living with HIV from the spectrum AIDS impact model, AIDS 2017, 31 (Suppl 1):S13-22). Different patterns are available by region. To enter your own pattern, change the region to 'Custom'. You can also eneter a time trend in mortality rates that will allow the set of mortality rates to change with time.

ART initiation by age. The distribution of new pediatric ART patients is based on data provided by CIPHER (Collaborative Initiative for Paediatric HIV Education and Research). Patterns are available by region. To enter your own pattern, set the region to Custom.

Effectiveness of cotrimoxazole. This editor shows the effect of cotrimoxazole on the HIV-related mortality. In settings with high prevalence of HIV and high rates of infectious diseases WHO recommends that cotrimoxazole be provided to all HIV-exposed infants and children starting 4 to 6 weeks after birth and continuing until the end of exposure to HIV and when it can be definitively determined that the child is not infected. For HIV+ infants and children cotrimoxazole is recommended for all children under the age of five, or those aged 1-4 years with WHO stage 2, 3, or 4, or CD4 percentage below 25. Children over the age of five follow adult guidelines (WHO stage 2, 3 or 4 or CD4 count < 350 cells/µl.'

The effect of cotrimoxazole is to reduce mortality by 33% in each of the first five years of treatment for those children who are not also receiving ART and, for those receiving ART, to reduce mortality by 33% in the first year, 16% in the second year, 8% in the third year, 4% in the fourth year and 2% in the fifth year.

Weight bands. This editor shows the distribution of children on ART by age and weight band. This information is used to calculate the number of children on ART by weight band for purposes of estimating need for pediatric ART formulations. The default distribution was provided by CIPHER (Collaborative Initiative for Paediatric HIV Education and Research) based on an analysis of 73,600 patients.

7.2.3.4.2 HIV progression and mortality without ART

New adult infections are tracked over time by their CD4 count, mortality and ART status as shown in Figure 3 below.

Figure 3. Model of Adult HIV Progression
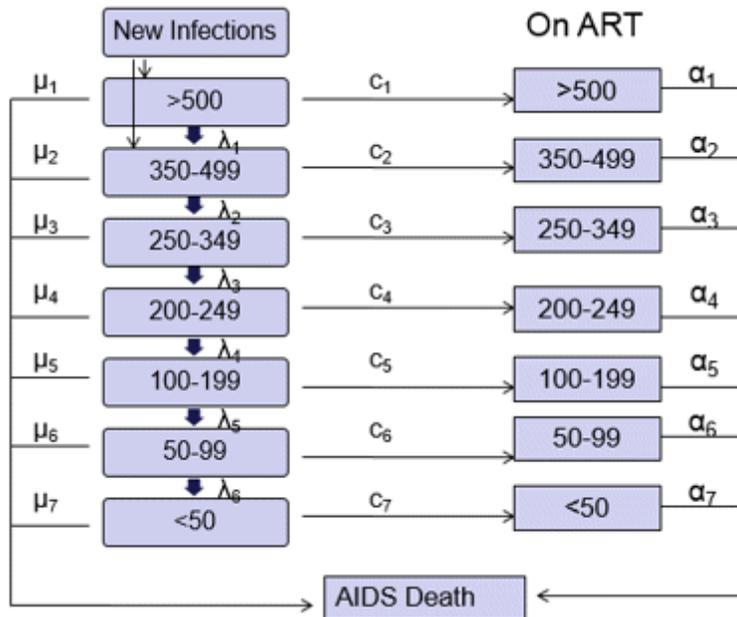
The transition rates are specified by the variables μ, λ, c, and α. They are defined as:

- μ, the annual mortality rate due to HIV
- λ, the annual rate of progression to the next lower CD4 count category
- c, the rate of initiating ART
- α, the annual mortality rate while on ART

To estimate the values for these parameters we relied on three major data sources.

1. **ALPHA network data on survival**. The ALPHA network is a collaboration of various cohort sites in sub-Saharan Africa (http://www.lshtm.ac.uk/eph/dph/research/alpha/). These sites follow community members over time to collect demographic and health information. ALPHA network researchers pooled their individual site data and analyzed them to determine the survival pattern of people infected with HIV who did not receive ART.[1,2] Those analyses showed a median survival time of about 11 years, with longer survival at younger ages than at older ages.

2. **Concerted Action on SeroConversion to AIDS and Death in Europe (CASCADE)**. CASCADE is a collaboration of 25 cohorts in Europe, Australia, Canada and sub-Saharan Africa. It

provided information on CD4 counts at zero conversion and estimates of mortality rates by CD4 count among untreated HIV-positive patients.

3. **Population-based HIV Impact Assessment (PHIA) surveys**. These surveys provide information on the distribution of the HIV-positive population by CD4 count.

Bayesian modeling was used to estimate progression and survival parameter values that would allow the AIM model to match PHIA data on the distribution of HIV-positive people by CD4 count. Details of the approach, assumptions and findings are available in Glaubius R, Kothegal N, Birhanu S, Jonnalagadda S, Mahiane SG, Johnson LE, et al. Journal of the International AIDS Society, 2021, 24(S5):e25784.

The final set of parameter values are shown in Tables 3, 4 and 5.

Table 3. Annual rate of progression to next lower CD4 count category by age

CD4 Count	15-24	25-34	35-44	45+
>500	0.153	0.183	0.225	0.286
350-500	0.251	0.286	0.333	0.402
250-349	0.348	0.395	0.461	0.556
200-249	0.650	0.740	0.862	1.040
100-199	0.294	0.335	0.390	0.471
50-99	0.500	0.569	0.664	0.800

Table 4. Distribution of new infections by CD4 count category and age

CD4 Count	15-24	25-34	35-44	45+
>500	60.54	57.35	53.95	50.35
350-500	20.76	21.86	22.90	23.83
250-349	10.77	11.84	13.02	14.29
200-249	3.63	4.08	4.58	5.17

100-199	3.71	4.20	4.78	5.47
50-99	0.51	0.58	0.67	0.77
<50	0.08	0.09	0.10	0.12

Note: These are the default data shown in the editor 'Years in CD4 count category'.

Table 5. Annual probability of HIV-related mortality when not on ART by age

CD4 Count	15-24	25-34	35-44	45+
>500	0.000	0.000	0.000	0.000
350-500	0.000	0.000	0.000	0.000
250-349	0.002	0.002	0.003	0.003
200-249	0.007	0.010	0.012	0.015
100-199	0.048	0.064	0.080	0.097
50-99	0.227	0.305	0.382	0.459
<50	0.712	0.954	1.197	1.439

Note: These are the default data shown in the editor 'HIV mortality without ART'. An annual mortality rate greater than one means that survival is less than one year.

7.2.3.4.3 HIV mortality with ART

Mortality on ART is based on the analysis by the IeDEA Consortium. These patterns result from an analysis of several hundred of thousands of patients from Eastern, Southern and Western Africa, Asia/Pacific and Latin America. The analyzes include adjustments for patients that were lost to follow-up. The final patterns describe annual mortality on ART by CD4 count at initiation, age group, sex, time on ART and region. The mortality rates can also vary by time as ART has become more effective with the introduction of new drugs and programs for retention and adherence. The editor contains a separate section for time trends in mortality rate. Full details of the data, methods and assumptions are available in Johnson et al. Global variations in mortality in adults after initiating antiretroviral treatment: an updated analysis of the International epidemiology Database to Evaluate AIDS cohort collaboration. AIDS 2019, 33 (Suppl 3):S282-S294

Many program have undertaken quality assessments of their ART program data. These assessments can show the amount of under-count or over-count in the data in the management information system. In order to use the results of these assessments, but at the same time maintaining the link to the data in

HMIS this editor also includes the option of entering a time-dependent adjustment factor that can adjust the program data for over- or under-count.

Figure 5 shows the final default patterns used in AIM. They show that mortality is generally higher for those initiating treatment at low CD4 counts compared to higher CD4 counts, for those recently initiating treatment compared to those on treatment for more than one year, for males compared to females, for the youngest and older age groups compared to those aged 25-44, and in southern Africa and West Africa compared to developed countries, Eastern Europe and Latin America.

Figure 5. Patterns of mortality on ART by age, sex and CD4 count at ART initiation for the southern Africa region for those on ART for more than 12 months
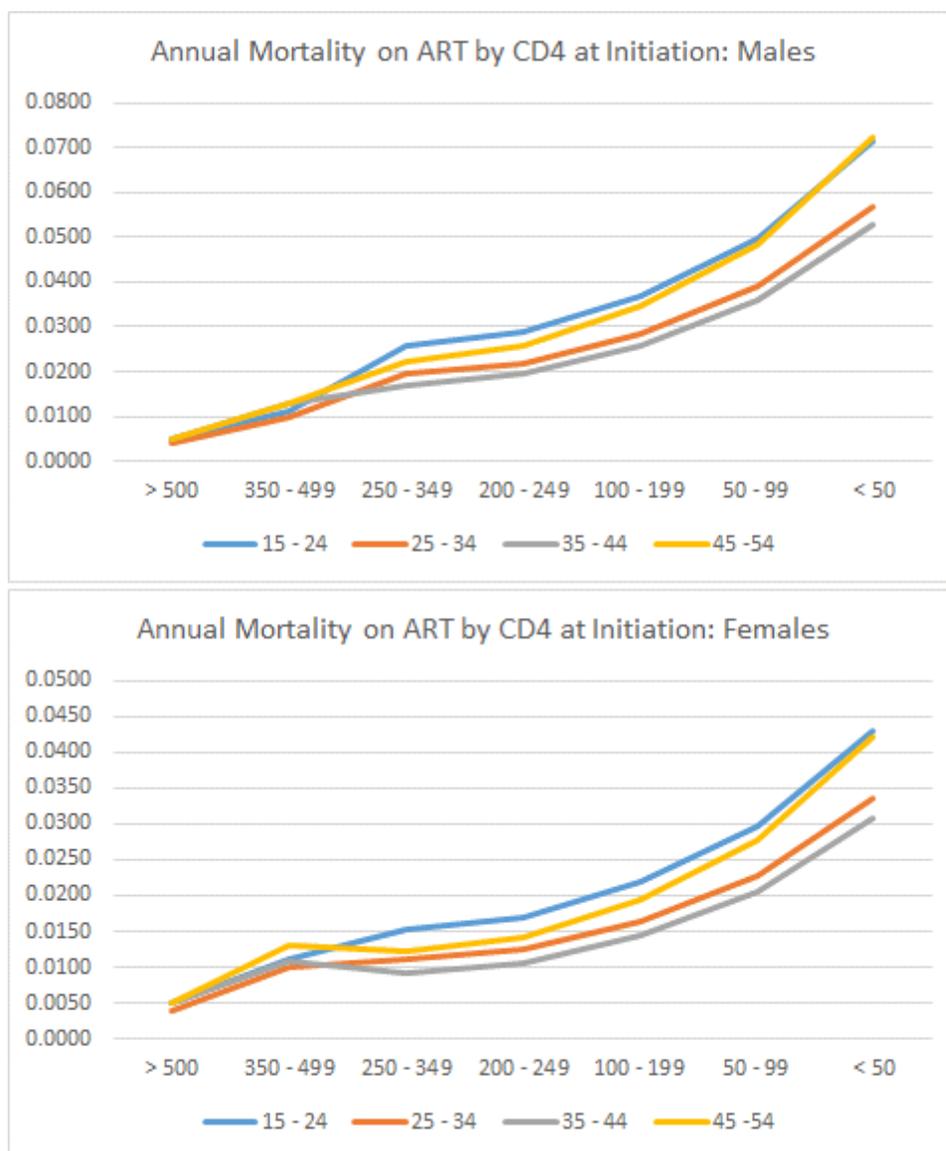
7.2.3.4.4 Effectiveness of cotrimoxazole

AIM considers two types of treatment for children: cotrimoxazole prophylaxis and ART. In settings with high prevalence of HIV and high rates of infectious diseases WHO recommends that cotrimoxazole be provided to all HIV-exposed infants and children starting 4 to 6 weeks after birth and continuing until the end of exposure to HIV and when it can be definitively determined that the child is not infected. For HIV+ infants and children cotrimoxazole is recommended for all children under the age of five, or those aged 1-4 years with WHO stage 2, 3, or 4, or CD4 percentage below 25. Children over the age of five follow adult guidelines (WHO stage 2, 3 or 4 or CD4 count < 350 cells/µl.'

The effect of cotrimoxazole is to reduce mortality by 33% in each of the first five years of treatment for those children who are not also receiving ART and, for those receiving ART, to reduce mortality by 33% in the first year, 16% in the second year, 8% in the third year, 4% in the fourth year and 2% in the fifth year.

[1] WHO. Antiretroviral Therapy for HIV Infection in Infants and Children: Towards Universal Access. A Public Health Approach. 2010 Revision. Geneva: World Health Organization, 2010.

[2] WHO. Guidelines on Co-trimoxazole Prophylaxis for HIV-Related Infections among Children, Adolescents and Adults: Recommendations for a public health approach. Geneva: WHO, 2006.

7.2.3.4.5 Progression from HIV infection to AIDS death in children

Progression and mortality of children is modeling in a manner similar to adults. HIV+ children are tracked by CD4 percent category for children aged 0-4 and by CD4 count category for children aged 5-14. Values for progression rates and HIV-mortality without ART were determined by fitting to survival by timing of infection. Studies of HIV+ children have shown that survival depends on the timing of infection. Marston and Becquet fit double Weibull curves to the data allowing for time of infection to give a pattern of survival post infection for four groups: those infected at birth, at 28–179 days, 180–364 days and after 365[1-3]. Similar curves representing the survival of HIV negative children from the equivalent time points were used to remove non-AIDS mortality. There is limited information about the survival of HIV infected children beyond 2.5 years, so as with the previous estimates it was assumed that beyond this point the survival for children would be equivalent to that of young adults infected at ages 15–24, with a median survival of 15 years. Survival is described as a double Weibull curve of the form:

$$S_t = (\pi \times e^X + (1 - \pi) \times e^Y) \times 100$$
where
$$X = -1 \times (\lambda_1 \times t)^{\mu_1} \text{ and } Y = -1 \times (\lambda_2 \times t)^{\mu_2}$$

The parameter values are shown in table 6.

Table 6. Parameter values for child survival patterns

Parameter	Time of Infection			
	Perinatal	Postnatal 0-180 days	Postnatal 181-365 days	Postnatal 365+ days
π	0.646	0.440	0.248	0.048
λ1	1.336	1.015	1.241	1.873
μ1	1.062	1.484	2.110	1.708
λ2	0.058	0.058	0.058	0.058
μ2	2.195	2.200	2.200	2.200

The resulting curves give a median AIDS only survival of 1.1, 6.4, 11.5 and 14.1 years resulting in 9% survival at 20 years for those infected at birth and 14%, 19% and 24% for those infected through breast feeding at 28–179 days, 180–364 days and after 365 days (figure 6).

Figure 6. Percent of HIV+ children surviving by number of years since infection
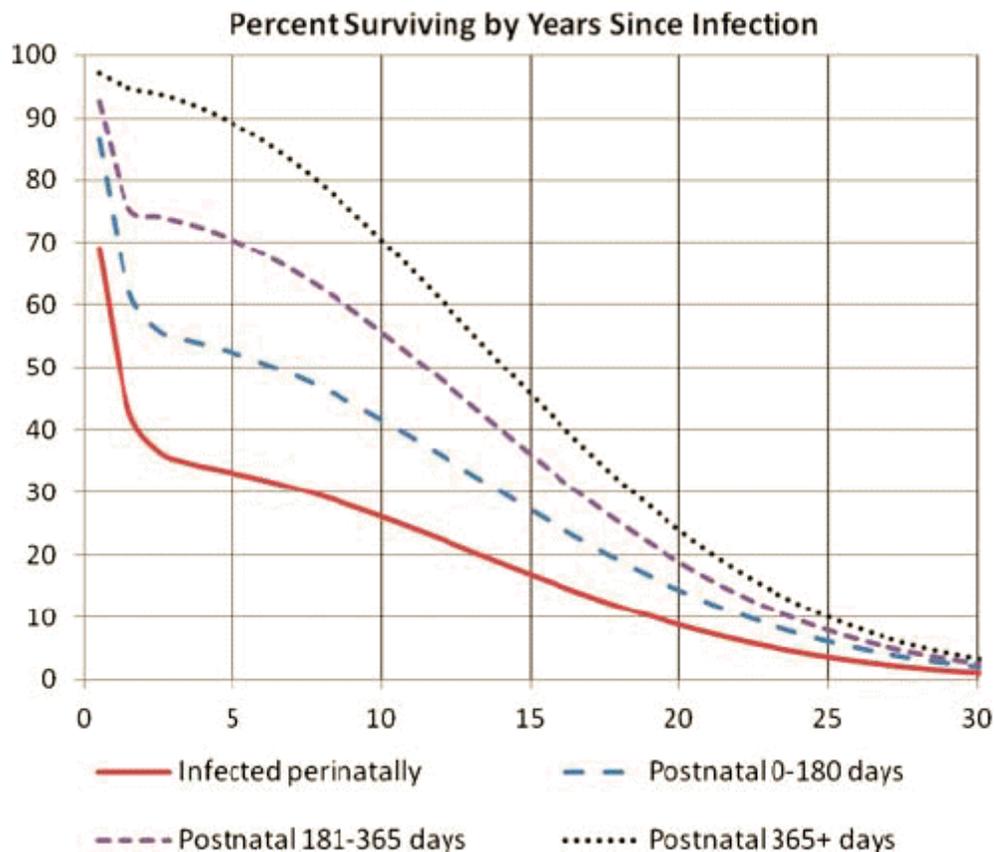
Estimates of mortality of children on ART were provided by the IeDEA Consortium.[4]

[1] Martson M, Becquet R, Zaba B, et al. Net survival of perinatally and postnatally HIV-infected children: a pooled analysis of individual data from sub-Saharan Africa. *Int J Epidemiol* 2010;40:385–96.

[2] Stover J, Brown T, Marston M. Updates to the Spectrum/Estimates and Projection Package (EPP) model to estimate HIV trends for adults and children. *Sex Transm Infect* 2012;88:i11–i16. doi:10.1136/sextrans-2012-050640

[3] Marston M, Todd J, Glynn JR, et al. Estimating 'net' HIV-related mortality and the importance of background mortality rates. *AIDS* 2007;21(Suppl 6):S65–71.

7.2.3.4.6 HIV-related fertility reductions

A number of studies in sub-Saharan Africa have examined the fertility of HIV-infected women compared to women who are not infected. These studies generally show that fertility is lower in HIV-positive women than in HIV-negative women between the ages of 20-45. It is generally higher for HIV-positive women aged 15-19 because they are all sexually active whereas many HIV-negative women in this age group are not sexually active. An analysis of data from national surveys calculated this information for 20 countries and found that the average ratio of fertility among HIV+ to HIV- women drops from 0.79 among women 20-24 to just 0.58 among women 40+ (table 7). For women 15-19 the ratio depends on the proportion that are sexually active. A recent analysis of data from the ALPHA Network cohort sites demonstrated that the CD4 count of the mother is an independent determinant of fertility of HIV+ women[3]. Spectrum includes both factors to estimate the fertility reduction due to HIV infection.

Table 7. Ratio of fertility among HIV-Infected Women to HIV-Uninfected Women

Age	Ratio	CD4 Category (not on ART)	Ratio	CD4 Category (On ART)	Ratio
15-19		>500	1.0	<500	0.99
20-24	0.79	350-500	0.91	350-500	0.93
25-29	0.75	250-349	0.77	250-349	0.89
30-34	0.64	200-249	0.57	200-249	0.69
35-39	0.58	100-199	0.38	100-199	0.58
40-44	0.58	50-99	0.29	50-99	0.58
45-49	0.58	>50	0.28	>50	0.58

The '**Fit local adjustment factor**' button will find estimate the fertility reduction value to best fit to data on prevalence among pregnant women. After clicking this button, you will see a buttons for 'Read from EPP' and 'From program data'. These buttons allow you to automatically import prevalence among pregnant women from EPP or the ANC Testing editor, if you have entered it there. If no data are available the button will be gray and you will not be able to use this feature. If the button is active, you can click it to load the prevalence data, then press 'Fit fertility rate ratios'. Once fit is finished the new values will be placed into the editor. Using this tool will improve the match to prevalence among pregnant women and the estimated PMTCT coverage.

[1] Lewis J, Ronsmans C, Ezeh A, and Gregson S. The Population Impact of HIV on Fertility in sub-Saharan Africa. *AIDS* 2004; 18 (suppl. 2): S35-S43.

[2] Chen WJ, Walker N. Fertility of HIV-infected women: insights from Demographic and Health Surveys. *Sex Transm Infect* 2010;86(Suppl 2):ii22eii27. doi:10.1136/sti.2010.043620

[3] Eaton et al. Sub-fertility by stage of HIV infection. Presented to UNAIDS Reference Group, Nov 9, 2016, New York City. Analysis of ALPHA Network data from Masaka, Rakai, Kisesa, Manicaland.

7.2.3.5   Adult HIV incidence

Most applications of AIM use an incidence trend generated using EPP as described in the Calculating incidence section of the program tutorial. With this approach the incidence trend estimated by EPP is automatically transferred to AIM. The trend can be viewed by opening the Direct Incidence Input editor (Modules -> AIM -> Incidence -> Incidence options).

The model used in EPP to estimate incidence from prevalence is simpler than the model used by AIM in that it is a single sex model that uses only a single age group, 15-49. As a result using the incidence from EPP in AIM will not exactly reproduce the prevalence trend fitted by EPP. AIM adjusts for these differences by making small changes in incidence each year in order to match the EPP prevalence trend. These adjustments can be turned off by unchecking the 'EPP prevalence adjustment' box in the 'Direct incidence input editor'. Normally this adjustment should be on. However, it should be turned off for any analysis examining historical effects. For example, you can estimate the number of deaths averted by ART by creating two projections, one with actual ART numbers and one with no ART in any year. However, this

comparison will only work correctly if the 'EPP prevalence adjustment' is turned off, since otherwise AIM will ensure the same prevalence in both projections.

The EPP prevalence adjustment is normally small but could be large in a year in which ART coverage changed substantially. In order to avoid discontinuities in the adjusted incidence curve the adjustment can be limited. The maximum adjustment of 10 (which is the default) will produce the closest match to the EPP prevalence curve but may result in an incidence trend that is not smooth. A smaller maximum value will produce a smoother incidence curve but may cause the prevalence trend to deviate from the EPP prevalence curve.

A new version of EPP that does include age structure was added in 2017. At the moment this feature is only available for generalized epidemics and may still require the EPP prevalence adjustment.

Several other options are available to estimate incidence trends.

- **Direct incidence input**. If you have an incidence projection from another model you can select this option and enter the incidence trend directly.
- **AEM**. The AIDS Epidemic Model (AEM) can be used to estimate incidence trends from sexual and needle sharing behaviors. This option requires that you have already implemented the AEM model.
- **Case Surveillance and Vital Registration (CSAVR)**. This may be a better option than EPP in cases were surveillance and survey data are not available or are weak but that good program estimates are available from vital registration and program records on the number of AIDS deaths, new cases of HIV, and/or the number of people living with HIV. Once the program estimates are entered, the program will search for an incidence curve that results in the best fit to available program data.
- **Fit to mortality data**. If good estimates of AIDS mortality are available you can modify an EPP fit using this option. This option allows successive adjustment of the incidence curve in order to better fit the output to mortality estimates.
- **ECDC.** This option provides a link to import incidence from the ECDC HIV Modeling Tool.
- **Pediatric nosocomial infections**. This option allows you to specific the number of children infected nosocomially. These are infections acquired in the hospital usually through contaminated needles and syringes.

Case Surveillance and Vital Registration (CSAVR)

In cases where surveillance data are weak or not available but good program estimates are available the 'Case Surveillance and Vital Registration (CSAVR)' tool may be the best option. This tool will search for an incidence curve that allows Spectrum to match as closely as possible program estimates of AIDS deaths, new HIV cases and/or people living with HIV. To use this tool it is important that the program estimates be of high quality. The three inputs are:

- **People living with HIV**
  Total : The estimated number of people living with HIV in each year. This indicator should be left blank unless good estimates exist. If ART coverage is high and information is available on the number of people in care and not on ART then it may be possible to develop a good estimate of people living with HIV if there is some way to estimate the proportion never diagnosed or linked to care.
- **New diagnoses**
  Total : This is the number of new HIV cases diagnosed each year. Note that this should not include new AIDS cases unless it is clear that these cases were not also reported at the time of HIV diagnosis.

Mean CD4 count at diagnosis: The mean CD4 count at time of diagnosis. This information is used to estimate the lag time from new infection to diagnosis.
- **AIDS deaths**
  o The recorded number of AIDS deaths to the population of all ages each year. These data will normally come from vital registration. Completeness of vital registration should be relatively high and it is advisable that the data have been checked for mis-classification. Values should only be entered for years where good data are available. If vital registration has become relatively complete only in recent years then only those years with good completeness should be entered.

Once the data are entered, you can select from three options to fit incidence.

- **Fit incidence / logistic curve**. This option will fit incidence as a single logistic curve. It is appropriate when the trend in new case reports shows an continually increasing trend with no sign of decline.
- **Fit incidence / double logistic curve**. This option will fit a double logistic curve that describes incidence rising to a peak and then declining.

This option assumes that incidence trends can be described as a double logistics function of the form:

$$\text{It} = I(t) = \left[e^{\alpha(t-t_0)} \Big/ (1 + e^{\alpha(t-t_0)}) \right] \times \left\{ 2a \left[e^{-\beta(t-t_0)} \Big/ (1 + e^{-\beta(t-t_0)}) \right] + b \right\}$$

Where:

$I(t)$ = incidence at time t
α = rate of increase at the beginning of the trend
β = rate of convergence to the asymptote
t t_0 = the time of the inflexion point
a determines the peak incidence value
b = asymptote

This is a flexible curve shape that can model a variety of incidence curves. Initial values of the parameters have been determined for most countries. They are displayed on the screen. It is usually recommended to try the fit with these default initial values first. If you cannot get a good fit, you can try changing the starting conditions and re-running the fit. The incidence curve on the screen will change when you change these parameter values but the fit to the other indicators will not change until you click the 'Fit incidence' button.

- **Fit incidence / Second Order Segmented Polynomial**. This option is useful when the trend in new case reports shows several reversals of trend. It is a more flexible curve shape, but takes longer to run.

Once you fit the incidence curve, Spectrum will display the value of the Akaike Information Criterion (AIC). This statistics indicates how good the fit is compared to the number of degrees of freedom. In general, we expect the curves with more flexibility (double logistic and segmented polynomials) to fit the data better than the single logistic function but they may also fit to random fluctuations in the data. The AIC combines information about both the goodness of fit and the degrees of freedom to indicate which curve is better. The lower the value of the AIC, the better.

By default the fitting uses maximum likelihood (MLE) to determine the best fit. If that does not produce a good fit you may try changing to the MKS (minimum chi square) approach. The fit will usually converge

and display the final incidence trend which will be used in AIM. If it does not fit you will see an error message. In those cases you may try changing the initial parameter values and/or relax the constraints imposed on the incidence parameters. Also you can set conditions to constrain the fitted predicted or predicted indicator(s). If you press the 'Set conditions' button you will see another screen that allow you to do so. You can set conditions on people living with HIV, new cases and AIDS deaths to specify that an indicator has to be greater than or less than a particular value in a particular year. These conditions can help to exclude incidence curves that are not acceptable. The model usually converges with about 200 - 300 iterations. By default it will stop if it reaches 1000 iterations. You can change the limit in the 'Set conditions' screen.

7.2.3.6 HIV+ migrants

Spectrum will estimate the number of HIV+ migrants by assuming that HIV prevalence among migrants is the same as in the resident population. If you want something different, you can enter the number of HIV+ migrants directly using this editor. In this case, Spectrum will use these numbers and not its estimate.

7.2.3.7 Pediatric nosocomial infections

If there have been a significant number of nosocomial infections among children in some years, you can enter them in this editor. They will be added to the number of HIV-positive children in the appropriate years.

7.2.3.8 Age and sex distribution of infections

Adult HIV incidence trends estimated by EPP refer to new infections among adults aged 15 and up. For use in Spectrum these infections need to be distributed by age and sex. In recent years a number of national surveys have provided information on HIV prevalence by age for women aged 15-49 and men aged 15-59. Incidence by age can be estimated from two prevalence surveys spaced some years apart. The same approach can be used to estimate incidence by age from a single survey if prevalence is assumed to be stable over time. We applied this method to data from 32 surveys to estimate incidence by age and sex. We then transformed this information into the distribution of new infections by age. These calculations were done separately for countries with relatively large samples of HIV-infected people (those with HIV prevalence above 4%) and those with lower levels of prevalence. The curves for the 14 surveys from high prevalence countries were averaged to produce standard patterns. The curves for the 17 surveys from lower prevalence countries were smoothed to reduce fluctuations due to small numbers of HIV-infected people and then averaged to produce standard patterns for these countries. For countries with epidemics driven by transmission through needle sharing for drug injection the patterns were developed using data on new case reports provided by WHO.

While the distribution of new infections by age is a useful way to describe historical patterns using these distributions in AIM could produce future situations where the number of new infections exceeds the number of susceptible people in some age groups. To avoid the problem AIM uses the incidence rate ratio. This is the ratio of incidence at any age to incidence at the reference age group, 25-29. In this definition 'incidence' refers to the percentage of the uninfected population that becomes infected during the year.

The ALPHA network (http://www.lshtm.ac.uk/eph/dph/research/alpha/) conducted a special analysis for the UNAIDS Reference Group on Estimates, Modeling and Projections to determine the incidence rate ratios by age using pooled data from their cohort sites. The ALPHA patterns match well to the pattern for high prevalence countries estimated from national surveys, as described above, for ages 15-49. Since national surveys do not routinely collect data on people older than 49 (or have small sample sizes) the

ALPHA patterns provide a better pattern. Therefore. The final patterns used in AIM are derived from the ALPHA network for generalized epidemics, from the survey analysis described above for concentrated epidemics and from the ECDC data for IDU-driven epidemics. These patterns are shown in figure 7. They are assumed to remain constant over time.

Figure 7. Incidence rate ratios by age and epidemic type
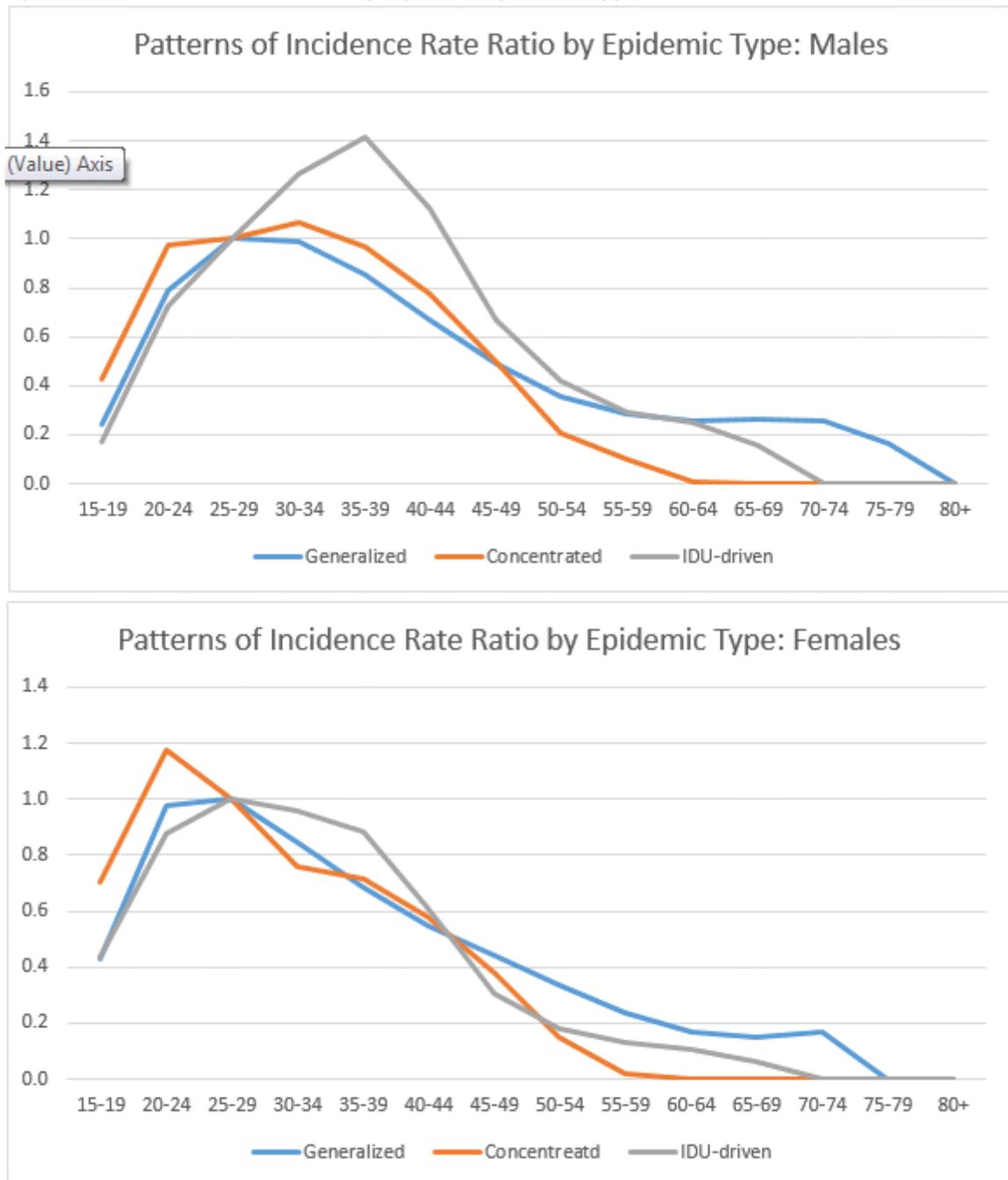
Adult HIV incidence is disaggregated into female and male incidence by specifying the ratio of new female infections to new male infections. We assume that the ratio is much less than one at the beginning of the epidemic but increases to greater than one for generalized epidemics about 10 years into the epidemic.

The population-based surveys show a wide variation in the sex ratio of incidence prevalence from just about o.5 in Niger to 2.4 in the Côte d'Ivoire. These data are shown in Figure 6. Based on these data we assume a ratio of 1.38 for generalized epidemics, 0.84 in most low-level and concentrated epidemics and 0.42 in IDU-driven epidemics (based on the ECDC data.

Figure 8. Ratio of new infections among adult females to new infections among adult males
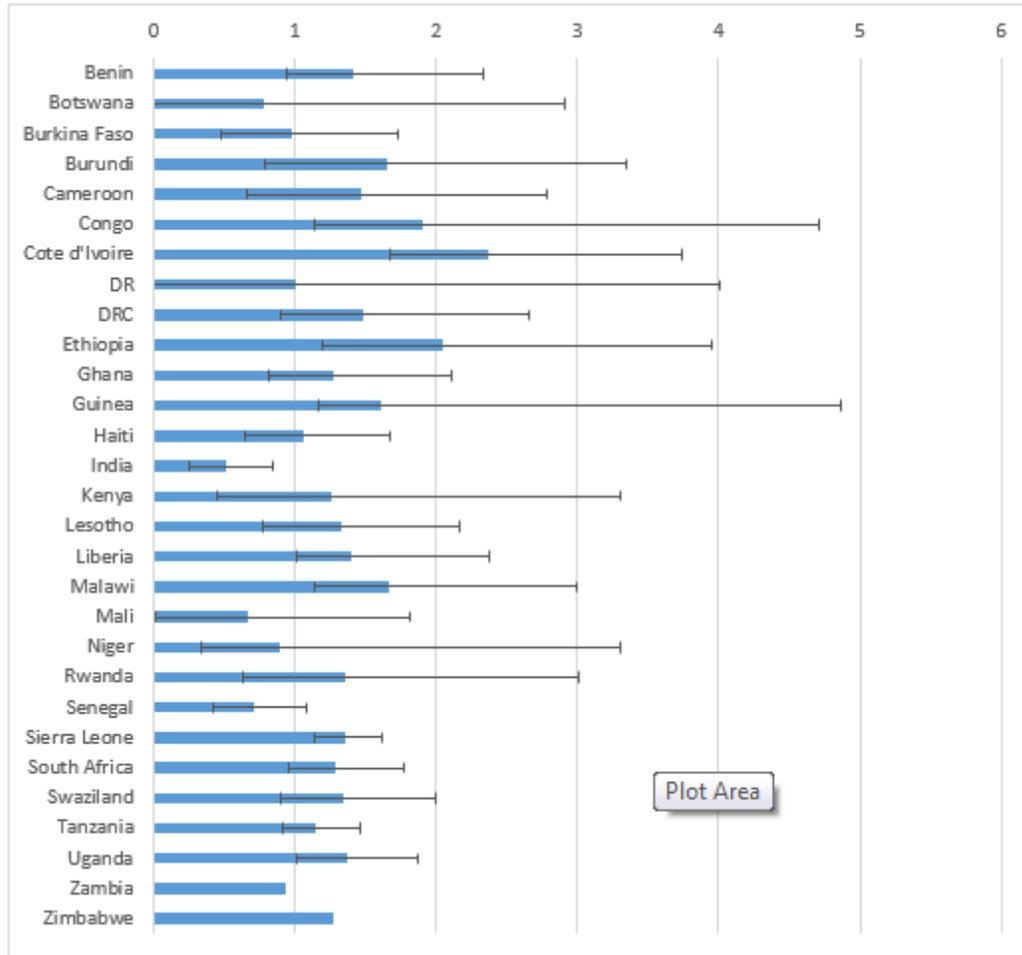
Fitting the Incidence Rate Ratio Pattern

For countries that have national surveys providing information on prevalence by age and sex, the Incidence Rate Ratios can be calculated by fitting to the survey data. If prevalence data are available in Spectrum's database then 'Fit incidence ratios' button will be active. To use this feature select the ratio button 'Fixed incidence ratios over time' then click the 'Fit incidence ratios button'. You will be able to fit incidence to survey data on prevalence by age or to data you have input on the number on ART by age. The program will try a large number of different patterns to find a pattern that best fits the selected data. Once it finishes that new pattern will be put into the editor and a value will be displayed for the Akaike Information Criteria (AIC). This statistic is a measure of the quality of fit. It depends on how closely the calculations match the data as well as the number of degrees of freedom used in the fit. A lower value for the AIC is better. More degrees of freedom raises the AIC as it increases the danger of over-fitting the data. If your country has more than one survey you can also try the option 'Time dependent incidence ratios'. With this option, the program will set a pattern from the first year to the time of the first survey and a second pattern for the time period between the first and second surveys. If there are more than two

surveys different patterns will be estimated for each inter-survey period. Once the fit is finished you can compare the AIC of the static fit with the time-dependent fit to determine which is better.

[1] Hallett TB, Zaba B, Todd J, Lopman B, Wambura M et al. (2008) Estimating incidence from prevalence in generalized epidemics: Method and validation *PLoS Med* 5(4): e80. Doi:10.1371/journal.pmed.0050080.

[2] European Centre for Disease Prevention and Control/WHO Regional Office for Europe: HIV/AIDS surveillance in Europe 2007. Stockholm, European Centre for Disease Prevention and Control, 2008.

[3] Zaba B. Age-specific pattern of incidence: ALPHA sites, 1995-2010, presentation to the UNAIDS Reference Group on Estimates, Modeling and Projections, Geneva, December 5, 2012.

[4] European Centre for Disease Prevention and Control/WHO Regional Office for Europe: HIV/AIDS surveillance in Europe 2007. Stockholm, European Centre for Disease Prevention and Control, 2008.

7.2.3.9   Orphans

AIM will estimate the number of AIDS and non-AIDS orphans caused by adult deaths. An orphan is defined as a child under the age of 18 who has lost at least one parent. These estimates are based on the fertility over time and the age at death of the parent. AIM will estimate maternal orphans (children whose mother has died), paternal orphans (children whose father has died), and dual orphans (children whose father and mother have both died). AIDS orphans are children who have lost at least one parent to AIDS. To estimate double AIDS orphans, AIM needs to estimate the proportion of couples with both parents infected with HIV. In sub-Saharan Africa, this estimation is based on a regression equation using data from national population surveys. These calculations are based on methods developed by Ian

Timaeus and Nicolas Grassly.'

Outside sub-Saharan Africa the estimation of orphanhood needs to be adapted for the fact that many of the AIDS deaths will occur to high risk groups, such as men who have sex with men, infecting drug users and sex workers, who may have fertility that is very different from the general population. The number of orphans is adjusted for the lower fertility of these groups. Since information on the fertility of these high risk groups is not readily available the proportion married may be used as a proxy.

[1] Grassly NC, Timaeus IM. "Methods to Estimate the Number of Orphans as a Result of AIDS and Other Causes in sub-Saharan Africa." Journal of Acquired Immune Deficiency Syndromes 2005 July 1; 39 (3) 365-375.

[2] Stover J, Johnson P, Hallett T, Martston M, Becquet R, Timaeus IM. The Spectrum projection package: improvements in estimating incidence by age and sex, mother-to-child transmission, HIV progression in children and double orphans *Sex Transm Infect* 2010;86(Suppl 2):ii16eii21. doi:10.1136/sti.2010.044222

7.2.4   AIM results

AIM outputs can be displayed by accessing the 'Results' menu (Modules -> AIM -> Results). The indicators are grouped by age group and by types. A complete list of indicators available and their definitions is given below.

Displaying All Age Groups in AIM

Displays under 'Total population' show indicators by age group. These include the HIV+ population, new infections, AIDS deaths and need for ART.

You can display the information as a table, 'Summary table', or as a population pyramid showing either numbers of people ('Pyramid (numbers)') or the percent distribution by age and sex ('Pyramid (percent)').

The pyramid display always shows two pyramids. If you are using a single projection, then the pyramids on both the left and the right will be for the base year. You can change the year for the pyramid on the right by clicking one of the buttons at the bottom of the screen to advance the pyramid one year ('Next'), show the previous year ('Previous'), show the first year ('First year'), or show the last year ('Last year').

If you have two projections loaded, then the pyramid on the left will display the first projection and the one on the right will show the second projection. Both pyramids will display the same year.

If you have more than two projections loaded, you will be asked to choose which two pyramids should be shown before the pyramids appear.

7.2.4.1 Dashboard

The dashboard display four indicators useful in tracking progress towards global goals. They are:

- **Number of new infections**. This chart shows the total number of new HIV infections in the total population from 2010 to the current year. The red dots represent the global targets, which are a 75% reduction from 2010 to 2020 and a 90% reduction from 2010 to 2030.

- **Number of AIDS deaths**. This chart shows the total number of AIDS-related deaths in the total population from 2010 to the current year. The red dots represent the global targets, which are a 75% reduction from 2010 to 2020 and a 90% reduction from 2010 to 2030.

- **Incidence - mortality ratio**. This chart shows the ratio of the number of new infections to the number of AIDS-related deaths. When this indicator drops below one, it means that the are fewer new infections than deaths and the number of people living with HIV is declining. Note that the critical value of 1.0 can be achieved by a reduction in new infections or a rise in AIDS deaths. Clearly reaching or dropping below 1.0 is only an indicator of success in controlling the epidemic when it is achieved by reducing new infections, not by increasing AIDS deaths.

- **Incidence - prevalence ratio**. This chart shows the ratio of new infections to people living with HIV. The critical value of 0.03 is based on the assumption that the life expectancy of a person living with HIV but on ART is about 33 years. Thus, if new infections drop to less than 3 percent of the number of people living with HIV then the epidemic is declining.

Note that both the Incidence - mortality ratio and the Incidence - prevalence ratio are indicators of whether the epidemic is under control (which should lead eventually to ending AIDS as a public health threat sometime in the future) while the number of new infections and AIDS deaths are direct indicators of progress towards ending AIDS as a public health threat.

7.2.4.2 Number of infections and deaths

One indicator of epidemic transition is when the annual number of new HIV infections drops below the annual number of deaths to people living with HIV. This display puts both of these indicators on the same chart so that this comparison can be made easily. .

7.2.4.3 Total population

- **HIV population:** The total number of people who are alive and infected with HIV.
- **HIV age distribution:** The number of infected people, by age and sex. This information can be displayed as a table or a pyramid chart.
- **HIV age distribution 0-80+**: This display allows you to set a custom age range by setting the low age and high age you want to display.

- **Number of new HIV infections:** The total number of new HIV infections each year.
- **New infections by age:** The number of new infections by age and sex and incidence by age and sex.
- **New infections by age distribution 0-80+**: This display allows you to set a custom age range by setting the low age and high age you want to display.
- **Incidence per 1000:** The number of new infections of all ages divided by the total uninfected population expressed in thousands.
- **Incidence per 1000 by age and sex:** The number of new infections at each age and sex divided by the uninfected population expressed in thousands.

- **Need for ART by age:** The number of people needing ART by age and sex each year. Need is defined as all those currently receiving ART plus those who are eligible but not yet on ART.
- **Number on ART by age:** The number of people receiving ART by age and sex at mid-year.
- **Number on ART by age distribution 0-80+**: This display allows you to set a custom age range by setting the low age and high age you want to display.
- **ART coverage by age**: The percentage of people living with HIV who are receiving ART by age.

- **AIDS deaths:** The annual number of deaths due to AIDS.
- **Cumulative AIDS deaths:** The cumulative number of AIDS deaths since the beginning of the projection.
- **AIDS deaths by age:** The number of AIDS deaths each year by age and sex.
- **AIDS deaths by age distribution 0-80+**: This display allows you to set a custom age range by setting the low age and high age you want to display.

- **Age-specific AIDS mortality (Mx).** The annual rates of age-specific mortality due to HIV/AIDS.
- **AIDS mortality per 100 thousand:** The number of AIDS deaths per 100,000 population.
- **AIDS mortality per 100 thousand by age and sex:** The number of AIDS deaths per 100,000 population by age and sex.

- **Total deaths to HIV population:** The number of deaths from all causes occurring to people living with HIV.
- **Total non-AIDS deaths to HIV population:** The number of deaths due to causes other than AIDS among people living with HIV
- **Total non-AIDS deaths to HIV population on ART:** The number of non-AIDS deaths to the HIV population on ART.
- **Total non-AIDS deaths to HIV population not on ART:** The number of non-AIDS deaths to the HIV population not on ART.

- **Disability adjusted life years (DALYs):** The total number of disability adjusted life-years for the total population.
- **Quality-adjusted life years (QALYs):** The total number of quality adjusted life-years for the total population.

- **HIV/AIDS summary:** A table the total HIV population, prevalence, new infections and AIDS deaths.

7.2.4.4 Adults (15-49)

- **HIV population:** The total number of adults between the ages of 15 and 49 who are alive and infected with HIV.

- **HIV population by risk group.** The number of HIV+ adults 15-49 by risk group. The risk groups are as defined in EPP. The number of HIV+ adults 15-49 is apportioned to the risk groups on the basis of the populations in EPP.

- **Adult HIV prevalence:** The percentage of adults (population aged 15 to 49) who are infected with HIV.

- **New HIV infections:** The total number of new adult HIV infections each year.

- **New Infections by Risk Group:** The number of new HIV infections by risk group as defined in EPP.

- **Incidence:** The percentage of uninfected adults who become infected in each year.

- **Annual AIDS deaths:** The annual number of adult deaths due to AIDS. Note that 'AIDS deaths' refer to any HIV-related death, whether or not the person would have met the clinical definition of AIDS at the time of death.

- **Annual AIDS deaths among those on ART.** The annual number of deaths to adults 15-49 who are receiving ART.

- **Annual AIDS deaths among those not on ART.** The annual number of deaths to adults 15-49 who are not on ART.

- **Annual AIDS deaths among pregnant women.** The annual number of AIDS deaths among HIV+ pregnant women.

- **Distribution by CD4 count - HIV+ not on ART (15-49).** The number of HIV+ adults 15-49 who are not on ART by their current CD4 count.

- **Distribution by CD4 count - HIV+ on ART (15-49).** The number of HIV+ adults 15-49 on ART by their CD4 count at the time of initiating treatment.

- **Adults 15-49 summary:** A table showing indicators just for adults 15-49.

7.2.4.5 Adults (15+)

- **HIV population:** The total number of adults ages 15 and greater who are alive and infected with HIV.

- **Adult prevalence:** The percentage of adults aged 15+ who are infected with HIV.

- **New HIV infections:** The total number of new adult HIV infections each year.

- **Incidence:** The percentage of uninfected adults who become infected in each year.

- **Annual AIDS deaths:** The annual number of adult deaths due to AIDS. Note that 'AIDS deaths' refer to any HIV-related death, whether or not the person would have met the clinical definition of AIDS at the time of death.

- **AIDS 45q15.** The proportion of HIV+ that will die from HIV-related causes between age 15 and 60 at the mortality rates prevailing in that year.

- **Annual AIDS deaths among those on ART.** The annual number of deaths to adults 15+ who are receiving ART.

- **Annual AIDS deaths among those not on ART.** The annual number of deaths to adults 15+ who are not on ART.

- **Number of AIDS related IDU deaths:** The number of deaths to HIV+ injecting drug users.

- **Number of non-AIDS related IDU deaths.** The number of deaths to HIV+ people who inject drugs that are not due to HIV.

- **Distribution by CD4 count − HIV+ not on ART (15+).** The number of HIV+ adults 15+ who are not on ART by their current CD4 count.

- **Distribution by CD4 count − HIV+ on ART (15+).** The number of HIV+ adults 15+ on ART by their CD4 count at the time of initiating treatment.

- **Total deaths to HIV population:** The total number of deaths occurring to people living with HIV.

- **Adults 15+ summary:** A table showing indicators just for adults 15+.

7.2.4.6   Adults (50+)

- **HIV population (50+):** The total number of adults aged 50 and older who are alive and infected with HIV.

- **New HIV infections (50+):** The total number of new adult HIV infections each year.

- **Annual AIDS deaths (50+)**: The annual number of adult deaths due to AIDS. Note that 'AIDS deaths' refer to any HIV-related death, whether or not the person would have met the clinical definition of AIDS at the time of death.

- **Adults 50+ summary:** A table showing indicators just for adults 15+.

7.2.4.7   Young people (15-24)

- **HIV population:** The total number of adults between the ages of 15 and 24 who are alive and infected with HIV.

- **Adult HIV prevalence:** The percentage of adults (population aged 15 to 24) who are infected with HIV.

- **Number of new HIV infections:** The total number of new adult HIV infections each year.

- **Adult HIV incidence:** The percentage of uninfected adults who become infected in each year.

- **HIV+ pregnant women.** The number of pregnant women aged 15-24 who are HIV+.

- **Annual AIDS deaths:** The annual number of adult deaths due to AIDS. Note that 'AIDS deaths' refer to any HIV-related death, whether or not the person would have met the clinical definition of AIDS at the time of death.

- **Annual AIDS deaths among those on ART.** The annual number of deaths to adults 15-24 who are receiving ART.

- **Annual AIDS deaths among those not on ART.** The annual number of deaths to adults 15-24 who are not on ART.

- **Adults 15-24 summary:** A table showing indicators just for adults 15-24.

7.2.4.8 Adolescents 10-19

- **HIV population:** The total number of people between the ages of 10 and 19 who are alive and infected with HIV.

- **Number of new HIV infections:** The total number of new adolescent infections each year.

- **Annual AIDS deaths:** The annual number of adolescent deaths due to AIDS. Note that 'AIDS deaths' refer to any HIV-related death, whether or not the person would have met the clinical definition of AIDS at the time of death.

- **Adolescent 10-19 summary:** A table showing indicators just for adolescents 10-19.

7.2.4.9 Children 0-14

- **HIV population:** The total number of children (0-14) who are alive and infected with HIV.

- **New HIV infections:** The total number of new child HIV infections each year.

- **Annual AIDS deaths:** The annual number of child deaths due to AIDS.

- **Population 0-14:** The number of children between the ages of 0 and 14 years old.

- **Number of HIV+ children not on ART by time of infection:** The number of children aged 0-14 who are not on ART by the timing of their infection: perinatal, 0-6 months after birth, 7-12 months after birth, more than 12 months after birth.

- **Distribution by CD4 percent - HIV+ not on ART (0-4):** The number of HIV+ children not on ART aged 0-4 by CD4 percent category

- **Distribution by CD4 percent - HIV+ on ART (0-4):** The number of HIV+ children on ART aged 0-4 by CD4 percent category

- **Distribution by CD4 count - HIV+ not on ART (5-14):** The number of HIV+ children not on ART aged 5-14 by CD4 count category

- **Distribution by CD4 count - HIV+ on ART (5-14):** The number of HIV+ children on ART aged 5-14 by CD4 count category

- **HIV-exposed but uninfected children**: The number of children aged 0-14 who are exposed to HIV infection because their mother is HIV-positive but who themselves are uninfected.

- **ART-exposed but uninfected children**: The number of children aged 0-14 whose mothers are HIV-positive and used ARVs to prevent mother-to-child transmission but who themselves are uninfected.

- **Child summary:** A table showing indicators just for children under the age of 15.

7.2.4.10 Children under 1

- **HIV population:** The total number of children under the age of one who are alive and infected with HIV.

- **Number of new infant HIV infections:** The total number of new infant HIV infections each year.

- **Infant AIDS deaths:** The annual number of infant deaths due to AIDS.

- **Summary table for children under 1:** A table showing indicators just for children under the age of one.

7.2.4.11 Children 1-4

- **HIV population:** The total number of children 1-4 who are alive and infected with HIV.

- **Number of new child HIV infections:** The total number of new HIV infections each year among children 1-4.

- **Children AIDS deaths:** The annual number of deaths due to AIDS among children 1-4.

- **Summary table for children 1-4:** A table showing indicators just for children aged 1-4.

7.2.4.12 Children under 2

- **HIV+ children under 2**. The number of HIV+ children under the age of 2.

7.2.4.13 PMTCT

- **MTCT by source.** This display shows the details behind the calculation of mother-to-child transmission. There are three display options: (1) the number of pregnant women receiving prophylaxis by regimen, (2) the number of new child infections by timing (prenatal or during breastfeeding) and pophylxis regimen and (3) the transmission rate by timing and regimen.

- **Mothers needing PMTCT:** The number of HIV-positive women giving birth each year and, therefore, in need of prophylaxis to prevent HIV transmission to the baby.

- **Mothers receiving PMTCT:** The number of HIV-positive women giving birth and receiving prophylaxis to prevent transmitting HIV to the baby.

- **PMTCT coverage:** The percentage of women needing PMTCT who are receiving it in that year.

- **PMTCT coverage of more efficacious regimens:** The percentage of women needing PMTCT who are receiving any prophylaxis regimen other than single dose nevirapine.

- **MTCT rate at 6 weeks:** The percentage of babies born to HIV+ mothers who are infected by 6 weeks of age.

- **Final transmission rate including breastfeeding period:** The percentage of children born to HIV+ mothers who will eventually be infected from their mothers at current transmission rates. This includes perinatal transmission and up to 36 months of breastfeeding.

- **Number of HIV+ breastfeeding women at 3 months:** The number of HIV+ women breastfeeding at 3 months postpartum.

- **Number of HIV+ breastfeeding women at 12 months:** The number of HIV+ women breastfeeding at 12 months postpartum.

- **Number of new child infections due to mother-to-child transmission.** The number of children who become infected due to transmission from their mothers.

- **HIV+ pregnant women with CD4 counts < 350.** The number of HIV+ pregnant women who have CD4 counts less than 350 cells/µl.

- **Treatment coverage for HIV+ pregnant women.** The percentage of HIV+ pregnant women receiving ART to treat their infection.

- **Number of infants diagnosed with HIV:** The number of HIV children under the age of one who are diagnosed with early infant diagnosis.

- **PMTCT summary.** A table with all PMTCT indicators.

7.2.4.14 ART

- **Treatment Cascade:** If you have entered data on knowledge of status and viral suppression then you can display the treatment cascade here. You can select from five population groups (children 0-14, adult males 15+, adult females15+, all age groups and all adults) and from three different displays: numbers (which shows the number of people in each group), % eligible 90-90-90 (which shows the percentage of the all PLHIV who know there status, the percentage of them who are on ART and the percentage of those on ART who are virally suppresed), or % of PLHIV (which shows each indicator as a percentage of all people living with HIV).

- **Detailed treatment cascade**: The detailed cascade displays show individual bars for knowledge of status, on ART and virally suppressed for a single year. These stacked bar charts show the composition of each group. This information may be useful for program planning to understand, for example, what proportion of those not on ART now where previously on treatment.

- **Total need for ART (15+) - (Dec 31):** Number of adults aged 15 and older who are eligible for ART, including those already on ART on December 31.

- **Total number receiving ART (15+) - (Dec 31):** Number of adults aged 15 and older who are receiving ART on December 31.

- **ART coverage of eligible population (15+) - (Dec 31):** The percentage of HIV+ adults 15 and older who are eligible for ART who are receiving ART on December 31.

- **ART coverage of all HIV+ adults (15+) - (Dec 31):** The percentage of all HIV+ adults 15 and older who are receiving ART on December 31.

- **HIV+ adults (15+):** The number of adults 15+ who are HIV+

- **Median CD4 count at ART initiation (15+):** The median CD4 of HIV+ adults starting on ART in each year.

- **Children needing cotrimoxazole (0-14) - (Dec 31):** The number of children eligible for cotrimoxazole on December 31.

- **Children receiving cotrimoxazole (0-14) - (Dec 31):** The number of children receiving cotrimoxazole on December 31.

- **Total coverage for cotrimoxazole (0-14) - (Dec 31):** The number of children eligible for cotrimoxazole who are receiving it on December 31.

- **Children needing ART (0-14) - (Dec 31):** The number of children eligible for ART, including those already receiving ART. on December 31.

- **Children receiving ART (0-14) - (Dec 31):** The number of children receiving ART on December 31.

- **ART coverage of eligible population (0-14) - (Dec 31):** The percentage of children eligible for ART who are receiving it on December 31.

- **ART coverage of all HIV+ children (0-14) - (Dec 31):** The percentage of all HIV+ children who are receiving ART on December 31.

- **HIV+ children:** The number of HIV+ children.

- **ART - Dec 31 summary (all ages):** Summary table showing all ART indicators for December 31.

7.2.4.15 Sub-populations

- **Sub-populations summary:** If EPP has been used to prepare the incidence trend, then AIM will display key indicators by sub-population. The sub-populations are those included in EPP. Sub-populations may be risk groups (e.g., sex workers, people who inject drugs) or sub-national regions.

7.2.4.16 AIDS impacts

- **Deaths averted by ART:** The annual number of deaths averted by ART. This is calculated by comparing the number of deaths in the current projection with one in which no one receives ART.

- **Infections averted by PMTCT:** The annual number of new infections averted by PMTCT programs. This is calculated by comparing the number of new child infections in the current projection with one in which no one receives PMTCT.

- **Life years gained by ART and PMTCT:** The annual number of additional life-years gained due to the effects of ART and PMTCT.

- **Deaths averted by ART (0-4):** The annual number of deaths to children 0-4 averted by ART.

- **Deaths averted by cotrimoxazole (0-4):** The annual number of deaths to children 0-4 averted by the use of cotrimoxazole.

- **Deaths averted by PMTCT (0-4):** The annual number of deaths to children 0-4 averted by PMTCT.

- **Impacts summary:** A table showing all of the impact indicators.

7.2.4.17 Orphans

- **Maternal AIDS orphans**: Children under the age of 18 who have lost their mother to AIDS.

- **Paternal AIDS orphans**: Children under the age of 18 who have lost their father to AIDS.

- **Dual AIDS orphans**: Children under the age of 18 who have lost both parents to AIDS.

- **All AIDS orphans**: Children under the age of 18 who have lost one or both parents to AIDS.

- **Maternal non-AIDS orphans**: Children under the age of 18 who have lost their mother due to causes other than AIDS.

- **Paternal non-AIDS orphans**: Children under the age of 18 who have lost their father due to causes other than AIDS.

- **Dual non-AIDS orphans**: Children under the age of 18 who have lost both their parents due to causes other than AIDS.

- **All non-AIDS orphans**: Children under the age of 18 who have lost one or both parents due to causes other than AIDS.

- **Maternal orphans**: Children under the age of 18 who have lost their mothers due to any cause.

- **Paternal orphans**: Children under the age of 18 who have lost their father due to any cause.

- **Dual orphans**: Children under the age of 18 who have lost both their parents due to any cause.

- **Total orphans**: Children under the age of 18 who have lost one or both parents due to any cause.

- **Orphans summary by age**: A table showing orphans by type and single age.

- **Orphans summary table**: A table showing all orphans by type and year.

- **Total new orphans**: The number of children newly orphaned each year.

7.2.5 Validation

The validation section of AIM is intended to facilitate comparing AIM output with other sources of data such a national surveys or vital registration. There are six validation sections:

- Prevalence
- Adult mortality (15+)
- Mortality by age (all ages)
- Adult ART (15+)
- Under 5 mortality rate
- Check file completeness

7.2.5.1 Prevalence

This section compares the pattern of prevalence by age as estimated by AIM with the pattern from a national survey. Data from most surveys are included in a database which you can read by selected the 'Read from database button'. The chart will look like the example below. The solid lines show the prevalence pattern estimated by AIM (red = male, blue = female) and the dots represent the survey data. The lines extending above and below the survey dots represent the 95% confidence interval for the estimate. If the AIM pattern does not match the survey well it may be necessary to modify the age pattern of incidence rate ratios.

Prevalence Comparison
Survey year: 2007

Male Survey data   Female Survey data   Male Spectrum output   Female Spectrum output
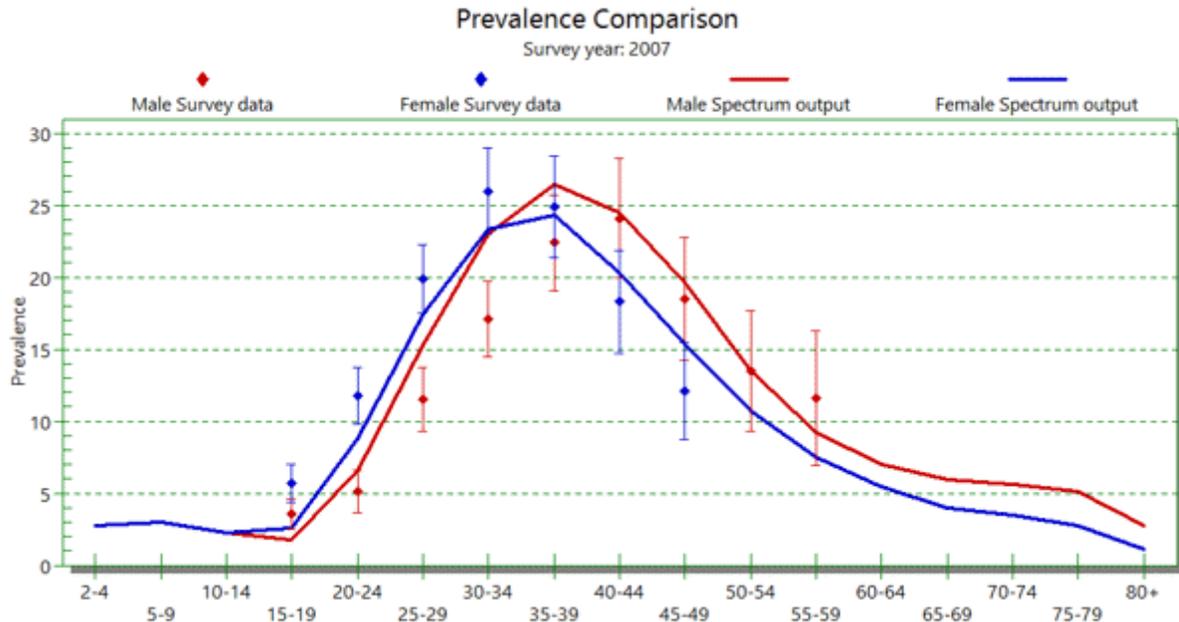
7.2.5.2 Adult mortality (15+)

This section compares the AIM output with other data that may be available for four indicators of adult mortality:

- **AIDS 45q15:** This is the probability for an HIV+ person of dying of HIV/AIDS between age 15 and 60 at the current age-specific mortality rates.

- **Non-AIDS 45q15**: This is the probability of dying of a non-AIDS cause between 15 and 60 at the current age-specific mortality rates.

- **Total 45q15**: The probability of dying from AIDS or non-AIDS causes between 15 and 60 at the current age-specific mortality rates. Spectrum includes a database of values from World Population Prospects 2015 which you can access by clicking the 'Read WPP Data' button.

- **Mortality rates by age**: This display compares mortality rates by age from Spectrum with those that you enter from another source.

7.2.5.3 Mortality by age (all ages)

- **All cause mortality:** This display compares mortality from any cause by age from Spectrum with data that you can enter from another source.

- **AIDS mortality:** This display compares mortality from AIDS by age from Spectrum with data that you can enter from another source.

7.2.5.4 ART

Most of the validation displays shown here have two sub-menus: 'Enter/edit data' and 'Comparison'. Use the 'Enter/edit data' option to enter program data or read survey data from the Spectrum database. Use the 'Comparison' option to display the Spectrum estimate and the program data or survey estimate.

- **Previously treated population:** See next page for explanation.

· **Number on ART**: This chart shows the number of people on ART

· **Number on ART by age**: This chart shows the number on ART by age as estimated by Spectrum compared to program data.

· **Number of adults and children newly starting ART**: This chart shows the Spectrum estimates of the number of adult and children newly starting ART which may be compared with program data.

· **ART coverage by age**: This chart compares the Spectrum estimate of ART coverage by age with survey estimates.

· **All-cause deaths among those on ART**: This chart compares the Spectrum estimate of deaths from all causes to people on ART with program data. Since program data often record deaths from any cause, rather than just AIDS, this may be the best comparison.

7.2.5.5   Previously treated

The previously treated population is people living with HIV who have been on treatment at some time in the past but are not on treatment in the reference year. The chart shows the number on ART (red line), the number of people living with HIV who are not on ART (blue line) and the number who are not on ART in that year but were on ART at some previous time. This display may be helpful for understanding whether most people who are not on ART now were previously treated or have never been on treatment.

The number previously treated is estimated as those previously treated last year plus those dropping out of treatment minus the number re-initiating treatment minus deaths among those previously treated:

$$PT[t] = PT[t-1] + LTFU[t] - RI[t] - PT[t-1] \text{ x } mr[t-1] \text{ x } mm$$

where:

$PT[t]$ = previously treated population in year t
$LTFU[t]$ = number dropping out of treatment in year t
$R[t]$ = number re-initiating treatment in year t
$mr[t]$ = annual mortality rate for those who have dropped out of treatment
mm = mortality multiplier expressing the ratio of mortality among those who have dropped out of treatment to PLHIV who were never on treatment

The number of previously treated who re-initiate treatment each year is estimated as the proportion of all PLHIV not on treatment who initiate treatment each year multiplied by the number previously on treatment last year and the probability of re-initiating treatment:

$$RI[t] = I[t] / NoART[t] \text{ x } PT[t-1] \text{ x } pr$$

where:
$NoART[t]$ = PLHIV who are not on treatment
pr = probability of re-initiating treatment among those who were previously on treatment

The number of people dropping out of treatment is the number previously on treatment multiplied by one minus the annual retention rate:

$$LTDU[t] = PR[t-1] \text{ x } (1 - rr)$$

where:

       rr   = annual retention rate

With this display you can change the annual retention rate (rr), the probability of re-initiating treatment (pr) and the mortality multiplier (mm) and see the results on the chart.

7.2.5.6   Under 5 mortality rate

This compares the Spectrum estimate of the under five mortality rate with an external estimate over time. A good source of under five mortality estiamtes is the IGME (Interagency Group for child Mortality Estimation) website at www.childmortality.org. The comparison chart looks like the sample below. The blue diamonds represent the external estimate and the red line is the Spectrum estimate.
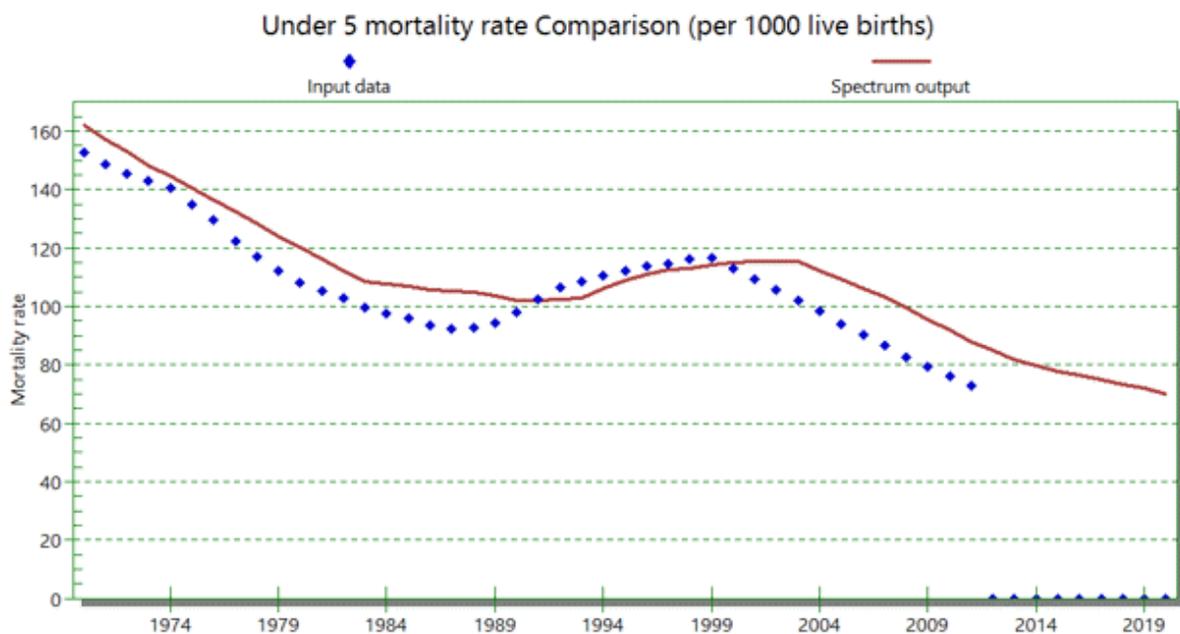
7.2.5.7   Check file completeness

Many types of data are required for a complete AIM application. It can be difficult to make sure that nothing is missed. The 'Check file completeness' tool checks 28 components of your file and reports 'True' for items that have been completed successfully and 'False' for items that are not yet complete. This is a quick way to review your file and focus your efforts on the areas needing attention.

7.2.6   Program tutorial

This program tutorial describes how to:

Create a demographic projection using data from the United Nations Population Division.

Create an HIV/AIDS projection using surveillance data.

Display various HIV/AIDS indicators such as the number of people infected, the number of new infections, AIDS cases, AIDS deaths, the number of people needing ART and the number of orphans.

7.2.6.1 Installing the program

The OneHealth program can be downloaded from www.AvenirHealth.org/software-spectrum.php. If you are installing Spectrum, it can also be downloaded from www.unaids.org. OneHealth will run on any computer running Windows 7 or later Windows versions. It requires about 300MB of hard disk space.

To install OneHealth from a file downloaded from the internet, just double click on the file named "OneHealthInstall.exe". This will start the installation program. Just follow the instructions on the screen to complete the installation.

If you have trouble installing OneHealth it may be that you do not have the appropriate permission to install programs on your computer. In that case you should contact your IT support office to do the installation for you.

7.2.6.2 Changing the language

The first time you run Spectrum after installing it, all the displays will be in English. You can change to another language, by selecting "File " then "Options" and under "Appearance" chose "Language" from the Spectrum menu. Then select the language you want to use and click on the "Ok" button. If you select a language other than French, Spanish or Portuguese you must have the proper fonts or version of Windows to display the language correctly.

7.2.6.3 Start the program

Start the OneHealth program by selecting it from the "Start" menu on your computer Windows 7 or earlier) or your Start Screen (Windows 8). When the program starts you will see an opening screen giving you the option to select 'New Projection', 'Open existing projection', select a 'Recently opened projection' or use 'OneHealth online support'.

If you have a projection file from previous rounds of estimates you can start with that file by opening an existing projection (skip to Displaying the AIM menus), or you can start over by creating a new projection.

7.2.6.4 Create a population projection

When you create a new projection you will see the "ProjectionProjection managerProjection manager" dialogue box, shown below.
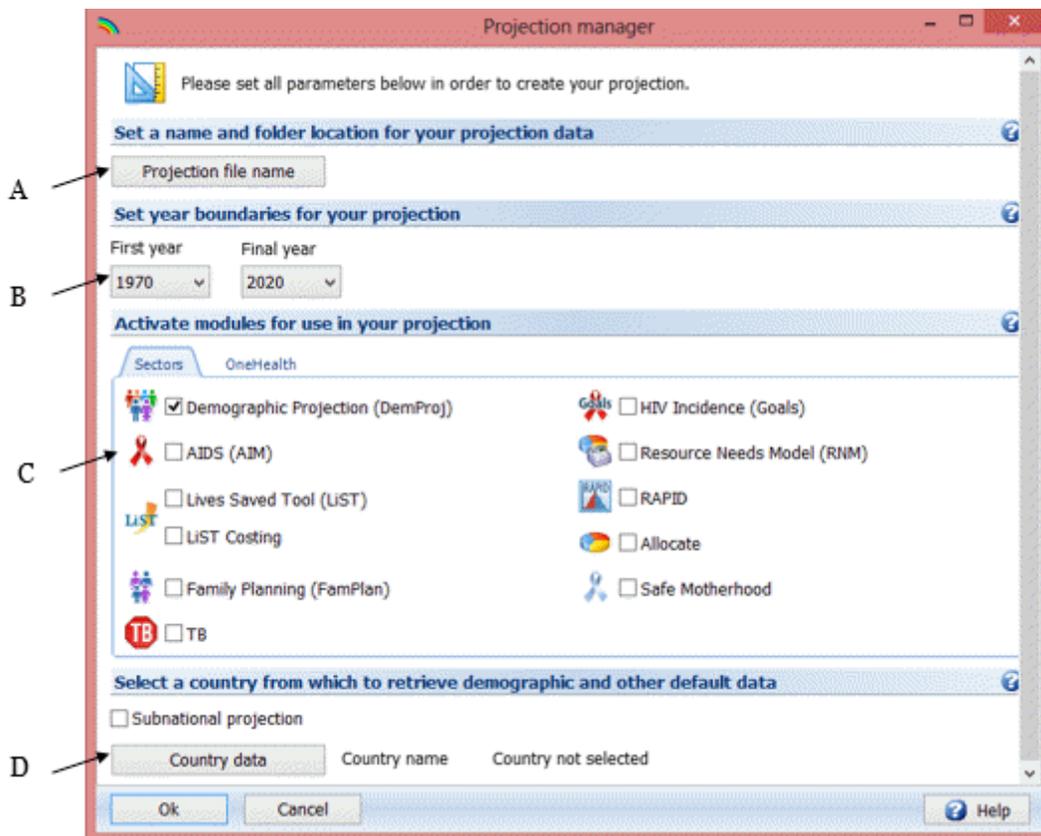
Follow these easy steps to complete the "Projection manager" screen:

A. Click the **ProjectionProjection file name** button and enter a file name for the projection.

B. The **First year** and **Final year** will be set to 1970 and 2020 by default. In most cases you should accept these values. You can change them if you wish, but projections submitted to UNAIDS should use the default settings.

C. Click the check box next to **AIDS (AIM)** to add the AIM module to the projection.

D. Then click the **Country Data** button. A list of countries will appear. Once you select your country from the list Spectrum will automatically load all the demographic data you need for your projection.

   In addition Spectrum now will load data on HIV incidence, and number of people receiving ART, cotrimoxazole and PMTCT services based on data published by UNAIDS and WHO. It is important that users compare these inputs with their program data and make any revisions that might be necessary. In particular, the data provided on PMTCT services should be reviewed.

E. When you are done click the **OK** button.

If you are updating an existing file you might want to extend the years of the projection. Select the Manager button then change the end year (i.e. from 2020 to 2025). Remember that projections more than five years into the future are unreliable.

7.2.6.5 **Display the AIM menus**

Select **Modules** from the Spectrum menu and click the **AIM** icon to display the AIM menu as shown below.
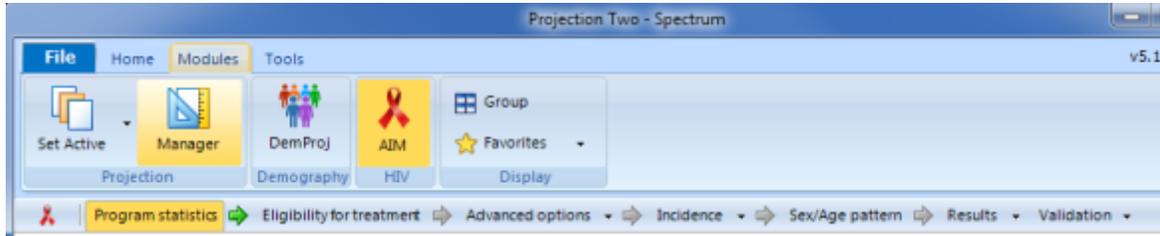
To produce the projection you just need to advance through these menu items one-at-a-time: **Program statistics**, **Eligibility for Treatment**, **Incidence**, **Sex/age pattern**, **Advanced options**, **Results, Validation**. The following sections explain each of these items in detail.

7.2.6.6 **Enter program statistics**

Click on the **Program statistics** menu item to see the program data editor. It will look like this:

Enter your program data using the three tabs at the top for: **PMTCT** (prevention of mother-to-child transmission of HIV), **men and women receiving ART**, and **Child treatment** (including ART and cotrimoxazole).

In each of these editors you may enter data as the *number* of people receiving the service or as *coverage*, the percentage of those in need of the service who receive it. If you enter coverage, Spectrum will calculate the number receiving the service when it makes the projection. Normally you will enter numbers from program statistics for all historical years. For the projection past the last year of program data to 2020 you may enter either numbers or coverage targets. You can enter numbers for some years and coverage for other years but you cannot mix numbers and coverage in the same year. Since the PMTCT editor has a number of rows you can use the drop-down menu in the upper right of the screen to select to show (1) just the rows for numbers, (2) just the rows for coverage or (3) both.

The grey numbers displaying the estimated number in need are based on the last time the projection was run. Substantial changes to the inputs (surveillance data or programme data) will result in a change in the calculation of the need. Consider the needs in grey as indicative values and review them after the whole file has been updated.

All OneHealth editors have **duplicate** and **interpolate** functions to make it easier to enter all the data required. To use these features just select a range of data with your mouse and either click the **Duplicate** or **Interpolate** buttons or right click with the mouse and select **Duplicate** or **Interpolate** from the menu.

- **Duplicate** copies the data from the first cell of the range to all the other cells in the range. It is useful when you want values to remain constant over time.

- **Interpolate** calculates values for the cells between the first and last cell in the range by interpolation. OneHealth will perform a linear interpolation if you click the Interpolate button. It you right click you will see a menu allowing you to choose the interpolation method: linear, S-shaped, exponential, and front loaded.

When you are finished entering data, click the **Ok** button.

7.2.6.7 Specify eligibility for treatment

Select the **Eligibility for treatment** menu item to see the editor shown below.

In the top part of the screen you can specify the eligibility for ART in terms of CD4 count. By default, eligibility is set to 200 cells/μl until 2010 and to 350 cells/μl for 2011 and later. You can modify these inputs to match your country's actual guidelines.

The second part of the editor allows you to specify that people living with HIV in certain population groups may be eligible for treatment regardless of CD4 count. Specify eligible populations by clicking the check box next to the name and set the year in which the guidelines were changed include that population group. Spectrum will calculate the number of HIV+ pregnant women but for all other groups you need to specify the percentage of HIV+ adults that are in that population group. Spectrum does contain default estimates for most countries.

For children eligibility has three components:

- **Age**. Enter the age below which all HIV+ children should be on treatment. By default this is set to 12 months from 2007 to 2009 and to 24 month thereafter.

- **CD4 count**. The CD4 count for eligibility can be defined by four age groups and by year. The default values follow WHO guidelines for the corresponding years.

- **CD4 percent**. Eligibility may also be defined in terms of CD4 percent by age. The default values follow WHO guidelines.

Children are considered eligible for treatment if they meet any of the three criteria.

7.2.6.8 Advanced options

The **Advanced options** menu item gives you access to the default parameter values used in the projection. These parameter values are based on special studies and surveys from a number of sites around the world. In most cases the default values should be used. This section allows you to see these default patterns, and change them if you have the information to do so. The patterns are grouped into four categories:

7.2.6.9   Calculating incidence

When you select **Incidence option** from the incidence menu you will see a drop down menu with five different fitting methodology options. The method that was used in the previous year should be selected by default.

If you are directly inputting annual incidence obtained from another tool, then select the 'Direct incidence input' options and then simply enter the incidence estimates and click Ok.

For countries that are using EPP, ensure EPP is selected in the drop down menu, then choose the age group that best reflects your surveillance data. For most countries with ANC surveillance or population survey data, this should be adults' ages 15-49 years. Also, for most countries, the box for EPP prevalence adjustment should be checked, which allows AIM to adjust for small differences in the prevalence trend fitted by EPP as compared to the trend fitted by AIM. The maximum adjustment factor of 10 will allow the resulting prevalence trend to closely match the prevalence curve from EPP. . A lower value of the maximum adjustment factor will produce a smoother incidence curve but the prevalence trend may differ from the curve fit in EPP.

The other options are:

- AEM. This option allows you to use AEM to determine the incidence trend. Generally it is used by only a few countries that already have AEM applications.

- CSAVR. This option estimates incidence by fitting to program estimates of the number of people living with HIV, AIDS deaths and new case reports. This option may be best for countries without good surveillance data but with good program data on case reports and AIDS deaths.

- Fit to mortality data. This option estimate incidence by comparing the model output to estimates of AIDS mortality from vital registration.

NOTE: If you are using EPP and do not have the Java Runtime installed on your system, the first time you go to run an incidence calculation, you will see the following prompt within OneHealth to download and install Java before proceeding:
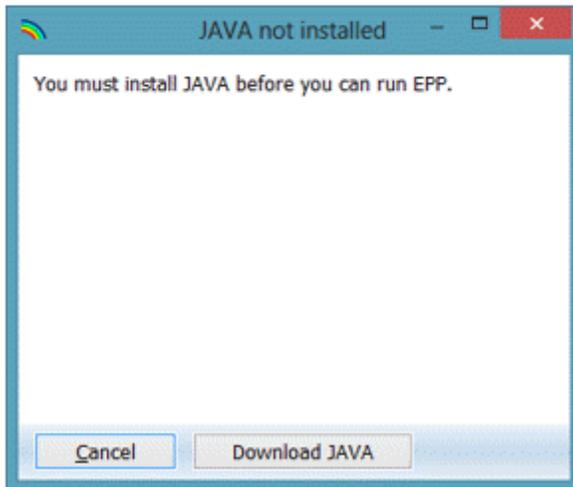
Click on "Download JAVA" and you will be taken to the Java site, where you can click on "Free Java Download" followed by "Agree and Start Free Download" to begin the install. When asked if you want to "run or save this file?", click on "Run" and follow the prompts to install the software.

As an alternative, you can visit the site java.com and install the Java software directly from there prior to running OneHealth.

7.2.6.9.1 Configuration (EPP)

This example show how to use the EPP model to estimate incidence. Other models that may be used are CSAVR, AEM or ECDC.

The first step under incidence is to define the epidemic structure of the country by selecting an appropriate template.

Define the epidemic structure.

1. Right click on the top entry under National epidemic structure. Select the appropriate template. There are three template options: Concentrated (C), From UNAIDS Workbook, and Urban/rural (G). For most countries with generalized epidemics use the Urban/Rural template. For most other countries, use the Concentrated template.
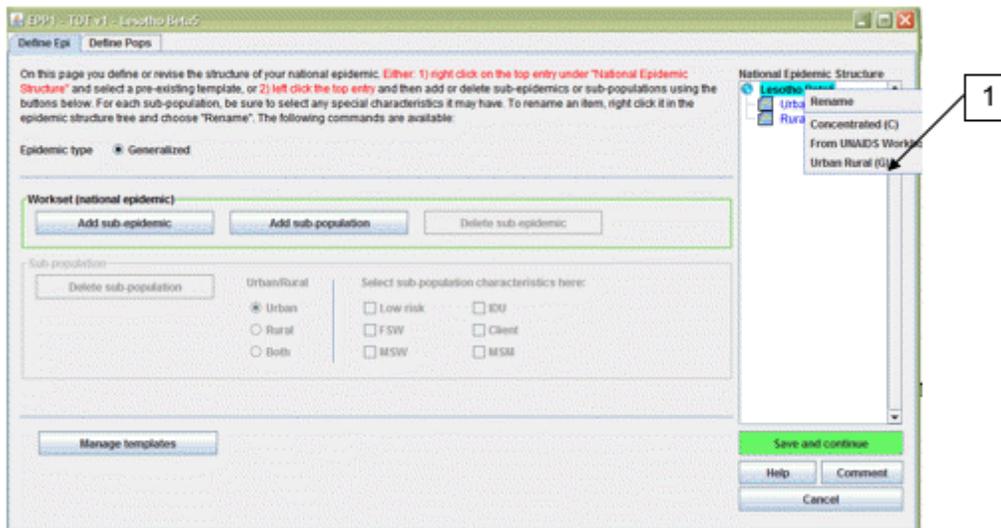
Alternatively, create a custom template by left clicking on the top entry and then add or delete sub-epidemics or sub-populations using the buttons to the left, as shown below. For each sub-population, be sure to select any special characteristics it may have. To rename an item, right click it in the epidemic structure tree and choose "Rename".

Define the sub-population characteristics

2. Highlight the sub-population in the epidemic structure.

3. Click on the characteristic of that sub-population (for examples sex workers should be "FSW" and the "General pop women" should be "low risk").

4. Repeat this for each sub-population

5. Click on "Save and continue"
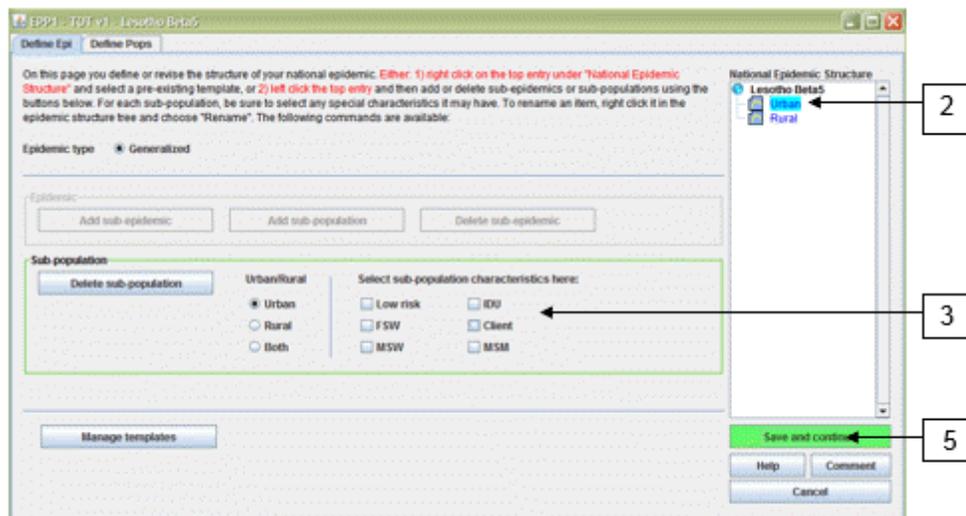
Generalised epidemics:

For many countries with generalised epidemics, one urban and one rural sub-population are sufficient to describe the epidemic. Alternatively you could create sub-epidemics by region if there are significant differences in regions of the country.

Box 1. Producing estimates for sub-national regions other than rural and urban

In some setting it might be necessary to create estimates based on sub-national regions to provide more specific estimates. Three options are available to help countries create sub-national estimates.

Option 1. Create a national Spectrum file using urban/rural configuration and apply the HIV prevalence by region through an excel sheet

Option 2. Create a national Spectrum file using sub-regions (instead of urban/rural) to fit curves and display a regional summary table within Spectrum

Option 3. Create separate regional Spectrum files

Option 1

Fit the epidemic curve using urban and rural for generalized and most-at-risk populations for concentrated epidemics. Prepare a single Spectrum file for the national projection. Use a spreadsheet to allocate key indicators by region (example available) based on regional prevalence from national survey or surveillance.

Use this option when there are few surveillance sites but one or more national surveys exist. The disadvantage is that estimates are only for regions with HIV prevalence in the national survey and it assumes epidemic dynamics are the same in each region of the country.

Example: Kenya district level estimates.

Option 2

Create an epidemic structure in the configuration page using regions. Assign the sites to each region and produce sub-epidemic curves for each region. Produce national curve in Spectrum. Use Spectrum's Regional Table output to see regional estimates.
Use this option when a number of surveillance sites are available in each region. This option captures the different epidemics for each region. However the indicators are only allocated on the basis of prevalence or incidence.

Option 3

Create one separate Spectrum file and curve fit for each region. Use the Spectrum Aggregate tool to produce a national estimate.

Use this option when there are many surveillance sites in each region and you have full epidemic information for each region (programme data, size estimates, non-AIDS population data). This option

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produces full epidemic information (all variables) for each region. However it requires that all of the demographic projection information is available by region.

Examples: Mozambique, India, China.

Concentrated epidemics:

For concentrated epidemics each sub-population created will require the following data: HIV prevalence data, estimates of the number of persons in the population, average time spent with the risk behaviour for those sub-populations of persons with high risk behaviour. Do not create sub-populations for which no data are available.

In concentrated and low level epidemics, if there are less than 3 data points from consistent surveillance sites for sub-populations at increased risk to HIV, then use the Workbook template. (As described earlier, you will need to derive point prevalence estimates for several years using Workbook and then will enter those into the incidence page to generate a curve.)

Tip: In countries with well documented concentrated epidemics in which HIV in the general population has increased beyond 1% (such as, Russia, Ukraine, Myanmar, Thailand), the concentrated epidemic template should continue to be used.

Define the populations

The **Define Pops** page allows you to define the size of each sub-population.

Generalised epidemic (urban/rural template):

In a generalised epidemic, when using the urban/rural structure, you define the number of the adult population in urban and rural areas by specifying the percentage of the population living in urban areas. If using the urban/rural structure, this is all you need to enter. The software already contains the United Nations Population Division values for each country and these are displayed when you first open this page. If you wish to change the urban percentages, you can by filling in the cells marked in blue. When done, click on "Save and continue" to store your results.

Generalised epidemic (user defined regions):

If instead you have created your national epidemic using a set of regional sub-populations, you will need to provide the population for each of those regions. The table will appear as shown below. At the bottom of the table is the total number of people aged 15-49 years in the population (based on the UN Population Division Non-AIDS estimates). You must assign all of this population to different groups within the epidemic structure.

6. For each region, enter the population for each year from 1970 to the end of the projection. Make sure the numbers for each year sum to the national total populations and that "Population still to assign" is zero for each column.

Tip: When you return to an existing Spectrum file and update the file with new demographic data, including overall population size, the population still to assign will no longer equal 0. To automatically adjust the population to the updated population figure select "Adjust for changed pop" and EPP will apply the same annual regional distribution to the new population.

7. When done entering all population, click on "Save and continue"

If you do not have populations for each year, but do know the percentages of the total population in each region in the starting and ending year, it is possible to have the software fill in the table for you. To do this:

8. Change to percentages by selecting "Percent" next to the word "Display:" at the bottom left-hand side of the page.

9. Fill in the percentages of the population in each region for the first year, 1970, in the table. Make sure that the percentages sum to 100% so that "Population still to assign" is zero.

10. Fill in the percentages for the final year, 2020, in the final column in the table. These need not be the same percentages, as the software will assume they grow or decrease according to the values you enter. Again, make sure that the percentages sum to 100% so that "Population still to assign" is zero.

11. Click on the button "Calculate Proportional Values" and the software will fill in the additional entries for the entire table.

12. Hit "Save and continue" to store your results and return to the AIM interface.

You can also use "Calculate Proportional Values" for the actual populations (instead of the percentages) if you have the total population in each region for the first year and final year. The procedure is the same: fill in the table for the first and last years, making sure that "Population still to assign" is zero for both years. Then click on "Calculate Proportional Values".

Concentrated epidemics:

For concentrated epidemics this page is more challenging. There are two sub-pages. On the first page the user should provide the estimates of the number of persons in each sub-population. Alternatively the percent of the adult population in each sub-population can be provided. These values can be changed over time if data permit. This is done exactly as previously described for generalized epidemics using user-defined regions.

6. Enter the estimated population size or the proportion of the adult (15-49) population in each sub-population by year (see previous section for a description of the procedure)

Box 2. Estimates of the size of key populations at increased risk to HIV (For low and concentrated epidemics)

The estimates of the size of key populations should be based on studies from the country. (Guidelines on how to estimate the sizes of most-at-risk populations are available at the UNAIDS website.) For clients of sex workers, consider using higher size estimates than those available from Demographic and Health Surveys or other population-based surveys. The West African Modes of Transmission project suggests that estimates of client of sex workers are higher than the estimates from these surveys, when calculated on the basis of estimates of number of sex workers combined with data on number of clients reported by sex workers.

Consider applying the percent of the population with increased risk to HIV (for example MSM or IDU) to only the urban population if these behaviours are relatively rare in the rural populations. Similarly, consider using a smaller percent when applying percent of rural population that are sex workers and clients of sex workers.

Some estimates of population sizes by region
(MSM and clients as % of male pop ages 15-49; FSW as % of female pop ages 15-49

Men having sex with men			Injecting drug users	
	General	High risk	E. Europe and C. Asia	0.06 – 5.21%
E. Asia	3 – 5%	<2.8%	E. Asia and the Pacific	0.021 – 1.33%
S & SE Asia	6 – 12%	1.2-7.2%	M East, N. Africa, SSA	0.05 – 2.07%
E. Europe	6 – 15%	1-5.5%	Latin America	0.29 – 1.15%
Latin America	6 – 20%	0.8-4.8%	& Caribbean	

Female sex workers		Clients of sex workers	
Sub-Saharan Africa	0.4 – 4.3%	All	9 – 10%
Asia	0.2 – 2.6%	Central Africa	13 – 15%
Russian Federation	0.1 – 1.5%	Eastern and southern Africa	10 – 11%
E. Europe	0.4 – 1.4%	Asia	5 – 7%
W. Europe	0.1 – 1.4%	Latin America	5 – 7%
Latin America	0.2 – 7.4%		

Source: Sexually Transmitted Infections, 2006 Jun; 82 (suppl)3; Mathers B et al Lancet 2008, 372:1733-1745.

For concentrated epidemics, additional information is required on the proportion of the sub-population that is male and the average duration an individual stays in the sub-population. These are used to calculate female/male ratios and to calculate the rate of turnover in the sub-population. This is provided on page 2 of the define populations page titled "% Male and Turnover" if you are using a concentrated epidemic template.

7. Indicate whether people are likely to move in and out of this sub-population. If you have evidence that there is a turnover in these groups (i.e. that sex workers move in and out of the sex work occupation) you should select the "on" button. Populations that are static such as the remaining populations will have no turnover.

8. Enter the estimated time (in years) that a person spends in that sub-population. This is used to determine the rate at which new members enter and old members leave the population. For example if it is set to 5 years, then 1/5 of the population must change every year, i.e., 20% of older members are replaced by newer ones. Sex workers in particular are known in most countries to have a short average duration (few years). See box 3

9. If turnover has been selected you will need to specify where the population will go after "turnover", or after they have left the most-at-risk population.

10. You also need to determine whether to add the prevalence of each sub-population to the overall prevalence or to replace it. You should choose "add prevalence" if those who are HIV positive from the former at-risk group members are added to the HIV positive members of the target population. This means they have NOT been captured in surveillance. You will need to "replace prevalence" if some of the people who are HIV positive in the target population are assumed to come from the former at-risk populations. The remaining infections that occurred "within group" are calculated. Identify the population to which the prevalence from the most-at-risk group should be added.

Box 3. Examples of adding or replacing prevalence in concentrated epidemics

replacing prevalence: Suppose we have former sex workers who are detected in antenatal testing. If we fit the data to ANC prevalence, then some of the prevalence here is due to former sex workers and some is due to other sources of infection, e.g., husband-to-wife or boyfriend-girlfriend heterosexual transmission. Thus, the HIV infections among ex-sex workers replace some of the detected prevalence in ANC women. They do not increase the overall prevalence rate among ANC women, but they do mean that less transmission occurred through the other routes of transmission.

adding prevalence: On the other hand men who injected drugs while young and then stopped are unlikely to be detected since we do not have routine surveillance in male populations. We do not detect these infections in our surveillance, but the infections are definitely still out there. We need to add these undetected infections into our total prevalence picture. For former male clients or injecting drug users then, we would want to add these additional infections into the overall prevalence in the male population.

Estimates of time in most-at-risk populations by region
Average duration of female sex work, by region

Region	Duration of behaviour in years
Africa	5.5 (4 studies)
Asia/Oceania	2.9 (12 studies)
North America	10.2 to 11.0 (3 studies)
Europe	8.4 to 10.0 (10 studies)
Latin America	11.2 to 12.0 (6 studies)

verage duration of injecting drug use, by region

Region	Duration of behaviour in years
Africa	5.6 (1 study)
Asia	8.7 (6 studies)
Oceania	17 (1 study)
Europe	13.9 (1 study)
North America	9.5 (1 study)
South America	21 or 19.6 (9 studies)

ource: Fazito E, Cuchi P, Mahy M, Brown T. Analysis of duration of risk behavior for key populations: a literature review. *Sex Transm Infec*   2012;**88**:i24-I32. doi:10.1136/sextrans-2012-050647.

7.2.6.9.2 Surveillance data (EPP)

Once the epidemic structure and populations have been defined it is time to enter the available HIV prevalence data. From the AIM menu choose: Incidence and Surveillance Data (EPP). This will take you to the Surveillance Data page. There is a separate data entry spreadsheet for each sub-population. When the page is initially open it only has one row (each row represents the data from one site).

1. Count the number of sites with data for the sub-population. Add rows on the data entry page by clicking on "Add sites" so that there is one set of rows per site. (For each site there is a row for the prevalence and a row for the sample size.) You can also add a number of sites at a time using "Add Multiple" and entering the number of sites to be added.

2. Enter the surveillance data: If the data are already available in a spreadsheet format it is easy to copy and paste the data into the workset. Copy and paste the site names into the far left column. Copy and paste the data into the page for that sub-population (e.g. for urban sites or for sex workers). When pasting the data, be sure that the years align correctly.

3. Press "Save and continue". If you forget this step you will lose the data that you have pasted into the page! Enter the data for all of the remaining sub-populations using the same steps as above. After you have saved the data for the last sub-population, you will be automatically taken to the Surveys tab.

Tip: If the sample sizes for each site are not available change the "Display" variable to be "% HIV". This will allow you to copy and paste just the prevalence information by site into the workset.

Tip: Prevalence estimates should be entered as whole numbers not as percentages. So prevalence of 12% should be entered as 12, not as 0.12.

Tip: Be sure the boxes on the left corner are ticked. If they are not ticked the site will not be included in the fitting of the model.

Tip: if you do not enter sample sizes, you will receive a message when you click "Save and continue" that will inform you that all samples sizes are being set to a default of 300.

Tip: If the prevalence for a site is 0% and this is an actual measured value (not one created to anchor the early prevalence), then leave it in the data set along with its sample size.

Tip: if you get a warning that the prevalence is too low for the sample size, you have entered a prevalence value that could not be determined from a set of measurements with the sample size you

provided. Please use a larger sample size that reflects the actual origin of the prevalence value. For example, one could not determine a prevalence of 0.5% with a sample of 100 as this would imply that only one-half a person was living with HIV.

4.   Enter survey data. If your country has collected HIV prevalence in a national population based survey you can add those data here to inform your curve. Data can be entered for up to 5 surveys. Be sure to include the prevalence, survey year, standard error, sample size for the survey, and the non-response rate for HIV testing (that is the percent of the total survey sample who did not receive an HIV test for any reason: refusal to provide blood, missing test, or not interviewed. In DHS reports this is 100% minus the "percentage interviewed and tested"). In some surveys the HIV prevalence results from national population based surveys can be biased because of persons refusing to take part in the survey or persons who are absent from the household at the time of the survey. Many surveys thus publish an estimate of HIV prevalence adjusted for any non-response bias. These adjusted values are available on the training workshop CD or in the published reports. HIV prevalence values which have been adjusted for non-response should be used in the model.

If your country does not have HIV prevalence data from a national population survey, click on the button labeled "Do not include any surveys in the fitting process".

7.2.6.9.3 Curve fitting

On this page the data entered in the previous pages are used to create an HIV epidemic curve and to analyze the uncertainty around that curve. There are three models that can be used for the curve fitting:

*   R-Spline: This will be the best model for most applications.

*   R-Trend: This will be the best model for countries with many years (8+) of surveillance data and many (7+) surveillance sites.

*   EPP Classic. This will be the best model for countries with few data points.

1.   Select the model you wish to use in the upper left portion of the screen.

2. If you are running the model as an exercise, click the "Training" button under "Purpose of run" a smaller number of curves will be calculated (400). If you are running the model as your final country estimation, click "For national projection" under "Purpose of run" which will increase the number of curves to 1,900. This number of curves will take much longer to run.

3. To produce the HIV incidence curve, click the green 'Fit' button. This will fit a curve for the sub-population selected. To run the curves for all sub-populations together, click 'Fit all' *after* selecting each sub-population in the list of sub-populations on the right and choosing the model to be used for each one.

4. Review the curve. The median curve will be shown as a red line and the 95% confidence intervals will be shown as blue dashed lines. Make sure the start year of the epidemic reflects the best understanding of the HIV epidemic in your country. This is especially important if you are using EPP classic or R-Trend.

5. If you are satisfied with the fit choose "Save and continue" and move on to fitting a curve for the next sub-population.

6. If you are not satisfied with the curve you can use the model parameters tab in the lower left of the interface to constrain the curves (see Box 4). For example if there is little data for early on in the epidemic, the model will often allow the curves to grow very quickly at the start of the epidemic. This can be constrained by limiting the prevalence in 1980 to <1% (or some appropriate value).

Box 4. Setting restrictions on prevalence curves

In some instances, where there is limited data, the models will find curves that are not realistic given what is known about the epidemic in your country. If the model produces curves that are not realistic, constraints should be placed on the curves using the Model parameters tab. Under this tab, you can: a) alter the range of possible start years to be more realistic for your country; and 2) apply conditions on prevalence that allow you to eliminate epidemiologically unrealistic sets of curves. These constraints on start years and prevalence should be used sparingly and with careful consideration of the following guidance:

1 *Before making prevalence conditions make sure the start year covers the full range of possible start years (a range of about 15-20 years)* . Normally, they should start up to 5 years before the first detection of local transmission of HIV or AIDS in your country and run until about 5 years after the first non-zero data point. This will give the models the flexibility they need to consider all possibilities. NOTE: this does not apply to R-Spline where the start year is already set in a country-specific way.

2 *Also before applying any prevalence conditions run the model without any constraints* . Then carefully examine the results to determine if there are curves which are absolutely outside the realm of possibilities given your data.

3 *Limit the number of prevalence conditions to the minimum number needed* to eliminate unrealistic curves. If you apply too many constraints you may eliminate curves that are legitimate fits to the data given its statistical uncertainties.

4 *Do not set lower constraints and higher constraints in the same year* . This will artificially restrict the uncertainty in your curves and they will not reflect the true uncertainty in your data.

5. ***Avoid setting restraints close to years in which data are available*** (within 3-5 years) if possible. If you must apply them in the available data range use them to reflect knowledge of allowable prevalence in the early stages of the epidemic when data was less available or to eliminate unrealistically high curves, e.g., 80-90% prevalence or 5 to 10 times the peak prevalence in the EPP fit during the data years.

6. ***Look at the resulting fit (red line with crosses) relative to the data in terms of deciding if the fit is reasonable*** and not necessarily the full range of possible curves (gray) some of which may be very high or low in future years. These high or low future values may reflect the true uncertainty in your epidemic's future when data are sparse.
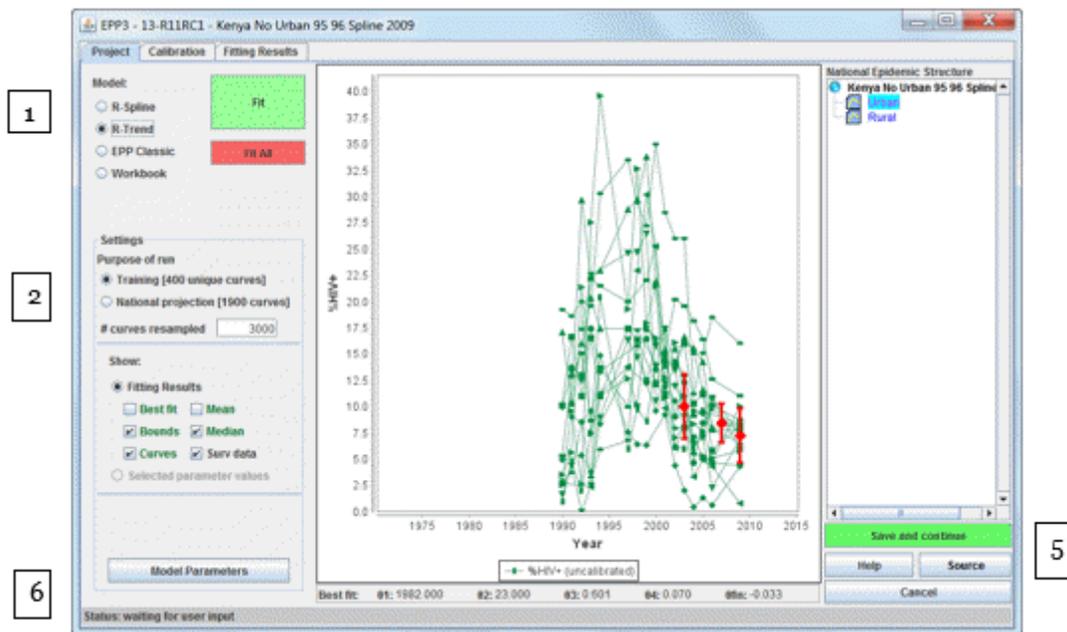
It is important to know that some calibration is normally done during the fitting procedure. If you have entered surveys in either a generalized or concentrated epidemic, they are used to adjust the final results of the calculation using a method that picks a best fit curve that is a good balance between the survey data and the observed surveillance data. It should be noted that this curve will not always pass exactly through the survey point itself – this is normal, do not be concerned by it. You can change it on the next page, the Calibration Page.

If you do not have surveys, but have marked your sub-populations as either urban or rural on the Define Epidemics page (or used the urban/rural template, which automatically sets these values), then downward adjustments will be made based on the observed urban and rural difference between national surveys and surveillance data in a large number of countries. Again, these adjustments are done automatically during the fitting procedure for generalized epidemics. For concentrated epidemics, no such global adjustments are made at present, although again normally some downward adjustment will need to be made for surveillance data done with women attending antenatal clinics. This adjustment can be made on the Calibration Page that follows the Project Page.

On the Calibration tab you can calibrate the curve based on additional data sources.
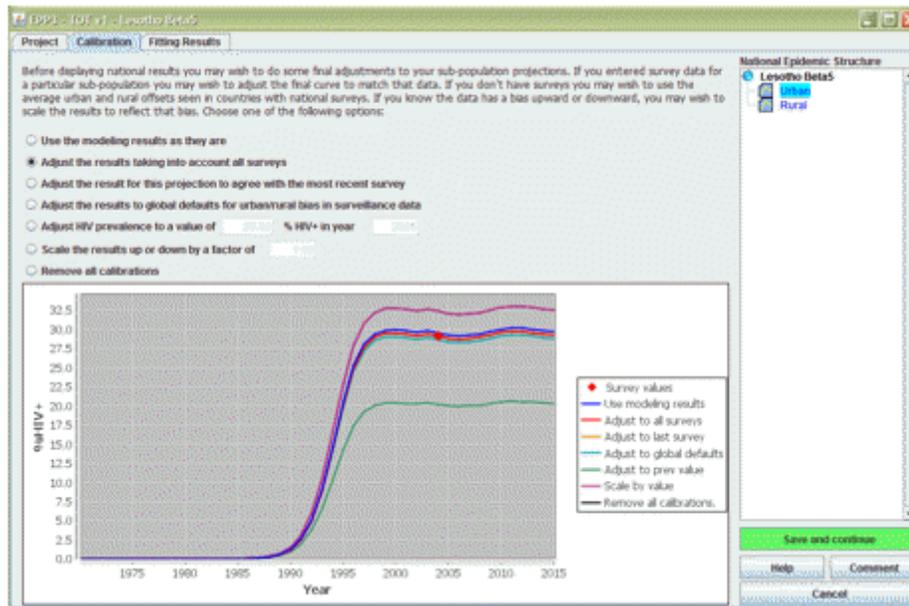
Generalised epidemics:

On this page you are able to adjust the curves based on any national population based survey data that you have entered. If you have had one or more national surveys then you can use all of the data from those surveys. Alternatively you could use the most recent survey if it better represents HIV prevalence than the earlier survey.

If you have not had a national population based survey then leave the default setting on "Use the modeling results as they are". As described earlier, this has already shifted urban and rural prevalence down to roughly 80% of the original value based on evidence from numerous surveys that ANC surveillance overestimates adult HIV prevalence.

There are additional options available for adjusting the curves, which are described in the next section, but these are not normally used in generalised epidemics.

Concentrated epidemics:

The calibration page gives you the option of specifying either an expected prevalence in a given year or a scale factor for each individual sub-population.

To use the calibration section:

7. Select the sub-population you wish to scale in the list of sub-populations shown

8. Select one of the options

    i. *Use the modeling results are they are.*   This option keeps the calibration that was established during the fitting.

ii.*Adjust the results taking into account all surveys.* This calculates an average offset between the EPP fitted curve and the survey values in the years where surveys are done. This is then applied to modeled prevalence curve.

iii.*Adjust the result for this projection to agree with most recent survey.* This calculates an offset that assures the adjusted EPP curve goes directly through the survey most recently completed and applies it to the modeled curve.

iv.*Adjust the results to global defaults for urban/rural bias in surveillance data.* In the case of generalized epidemics, this adjusts all urban and rural sub-population projections downward by UNAIDS-specified urban and rural amounts developed by comparing national surveys with ANC data in a number of countries.

v.*Adjust HIV prevalence to a user specified value.* This calibrates the best fit curve by multiplying all prevalence values by a constant number which ensures that the adjusted best fit curve goes through a user-specified prevalence value in a user-specified year. This might be the value from a more representative sample of the specific surveillance population, e.g., an IBBS study of female sex workers.

vi.*Scale the results up and down by a factor.* Choosing this option scales all prevalence by the user-provided provided number. For example, if you enter 0.5, it gives a prevalence curve with each value cut in half.

vii. Remove all calibrations. This removes all calibrations done during the curve fitting and uses the EPP curve without any upward or downward adjustments.

Box 5. Adjusting prevalence for the "remaining population" (low risk populations)

ANC prevalence can represent the remaining female population. However, when using surveillance data from ANC to describe the remaining female population the ANC estimate needs to be adjusted because women attending ANC are likely to have higher HIV prevalence because of biases in the geographic selection of antenatal clinics in the sentinel surveillance as well as a bias in the age of women attending ANC versus women in the general population. Comparing data available from ANC against HIV prevalence coming from population based surveys in 12 low and concentrated epidemic countries (or states), show that on average, HIV prevalence among all women was 60 percent of that measured in ANC prevalence. Thus a proposed adjustment value for women in the remaining population of **0.6** is required when assigning the ANC data to the remaining female population. The option "Scale HIV by factor of" should be chosen and 0.6 should be entered into the cell.

For men a similar analysis showed that the scale of HIV prevalence in the remaining male population is approximately 0.5 of ANC prevalence. Thus the adjustment from ANC data to men in the general population should be **0.5**. (Note that these adjustments are based on a small number of countries.)

If prevalence is available from a population-based survey (e.g. India, Cambodia, Dominican Republic, Senegal, or Mali) use the survey results to calibrate the general population prevalence.

Where universal PMTCT is standard practice (as in Russian Federation, Thailand, among others) it is possible to use these data to also inform the prevalence among the female remaining population. However it is important to standardize the data coming from the PMTCT system to the age structure of the general female population. Similarly if there are data on men from a universal service, such as mandatory military service, (which does not increase their risk to HIV) these data can also be used to inform prevalence among the male remaining population.

Once completed you should click on 'Save and continue' to move to the **Fitting Results** page. Here you can review the resulting prevalence trends by population type and also see the national trend that is produced by combining the trends for all the sub-populations. Just select the population you want to examine from the list at the top right of the page [A].
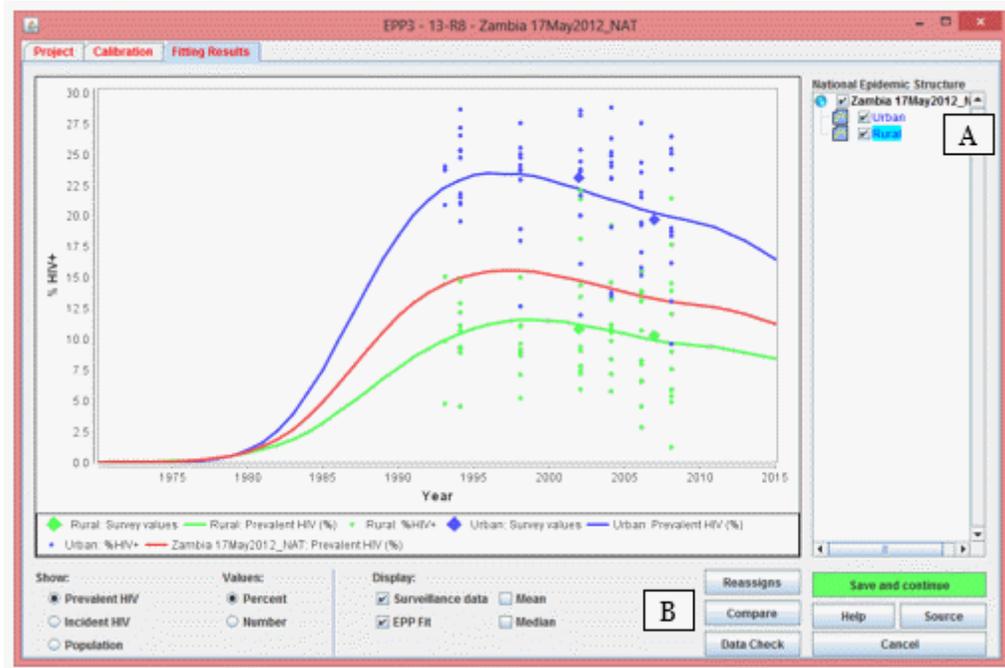
You may also compare your new results with the prevalence trends from a previous projection by clicking the 'Compare' button [B]. That will display a screen like the one shown below. You need to click the 'Load' button and select the comparison projection's OneHealth (*.SPT) file which contains the necessary information from the previous projection. Then the charts will compare your new projection (red) with the previous projection (blue) for prevalence, inciden

ce, population size and female to male ratio (for concentrated epidemics only, this will remain blank for generalized epidemics where female to male ratio is calculated within OneHealth). When you have finished viewing this page, close it by clicking the 'X' in the top right of the window.
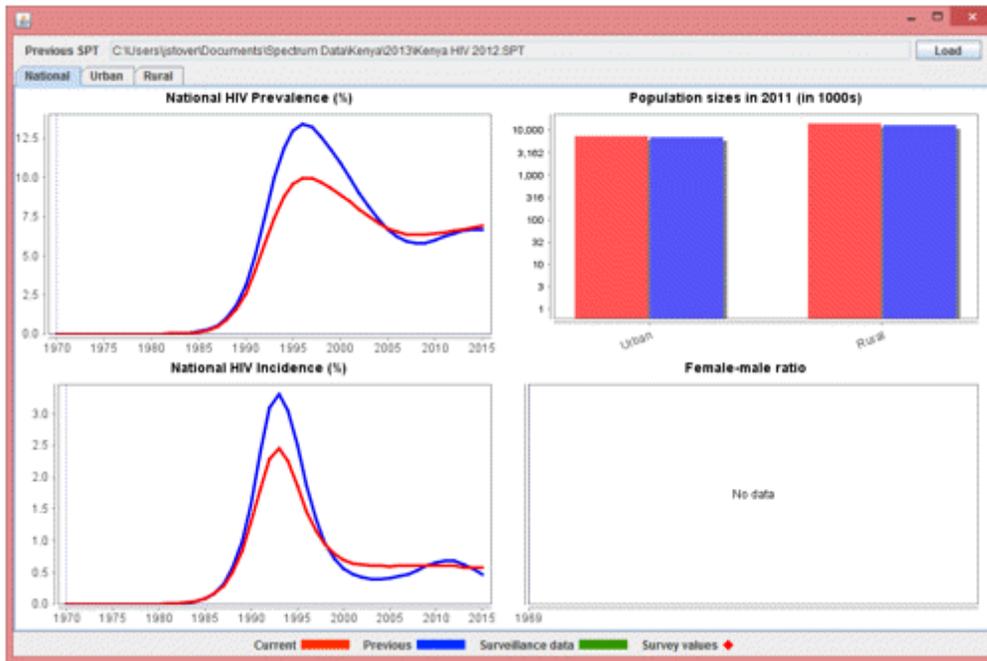
For some countries you will also be able to check the estimated number of AIDS cases or HIV infections (prevalence or incidence) from the new trend with program data on the reported number of AIDS and HIV cases. Select this option by clicking the 'Data Check' button. This will bring up the display shown.
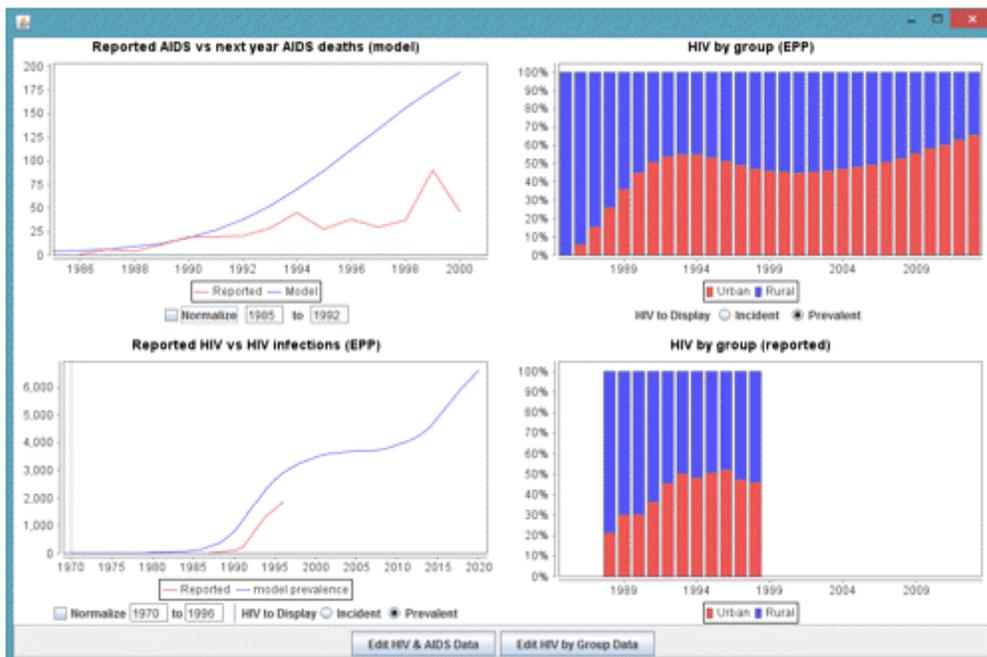
If you enter start and end years below the graph and check the box marked "Normalize", the reported and model data for those years will be adjusted to the same scale as can be seen by comparing the graphs below.
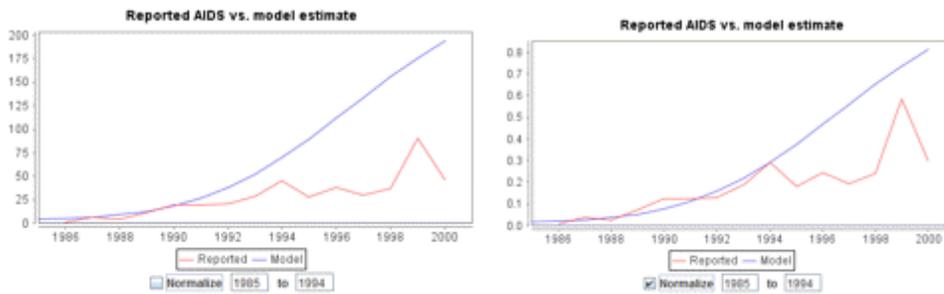
Once you have finished viewing the results click 'Save and continue' to move to the next step.

7.2.6.9.4 Direct incidence input

Direct input of incidence is used only when you already have an incidence projection that you want to use. In most cases you should go through the Configuration, Surveillance, and Curve fitting steps to create an incidence projection.

7.2.6.10 Set the pattern of incidence by sex and age

For concentrated epidemics the curve fitting process will produce an estimate of the sex ratio (the ratio of female prevalence to male prevalence). For generalized epidemics a default pattern will be automatically used that describes the general pattern of an increasing proportion of female infections reaching a ratio of 1.38 ten years after the start of the epidemic.

You can review the sex ratio trend by select the **Sex/age pattern** menu item. It will show a screen like this:
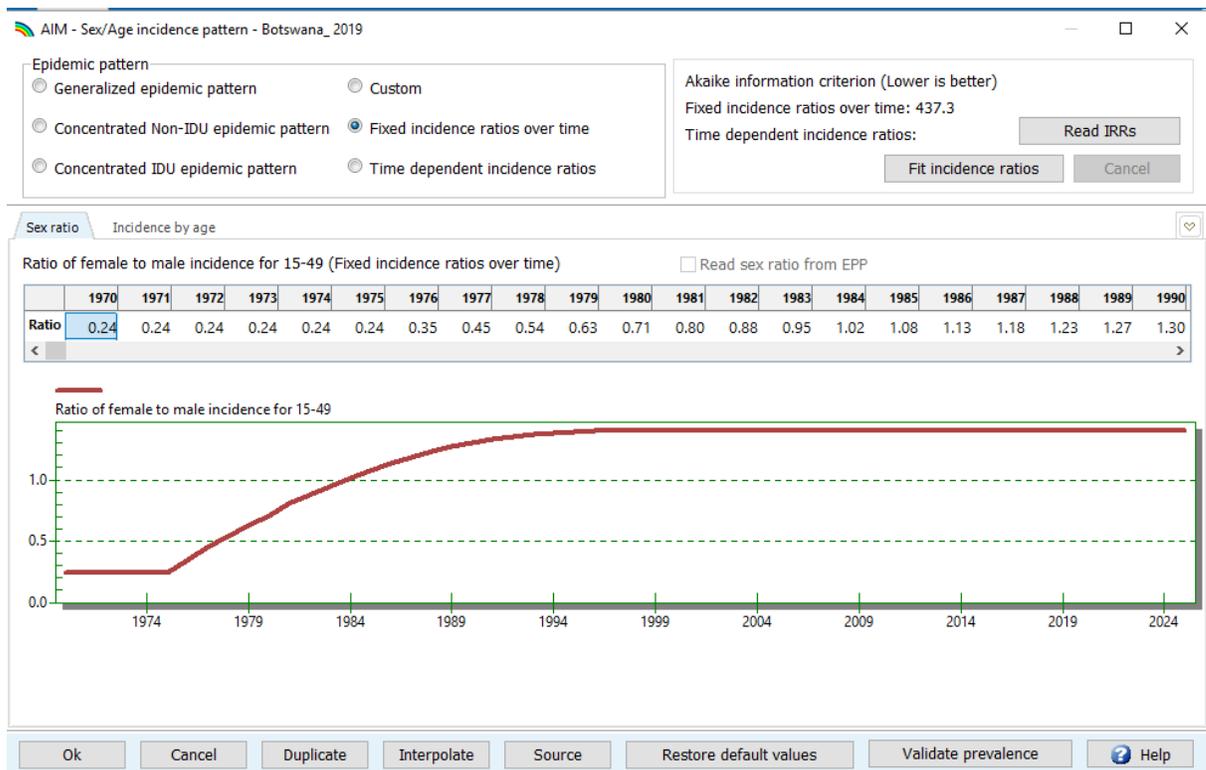
You should examine the chart and determine if this trend is appropriate for your country. If it is not, you can change the radio button to 'Custom' and enter a new patterns. If you have nationally representative household surveys in your country or region, you can use the tool to calculate the sex ratio and age patterns to match the survey data on prevalence by age and sex. If survey data are available then the 'Fit incidence' button will be active. In most cases you should set the radio button to 'Foxed incidence rate ratios over time' and then click 'Fit incidence'. If multiple surveys are available you can use the 'Time dependent incidence ratios' option. This will find the best patterns to match each survey. You can try both options and use the Akaike Information Criterion to choose between them. A lower number is better. This statistic combines information on how well the model fits to the data and how many changes in the pattern are required.

If you are using Spectrum to model a sub-national region you can either fit to the sub-national data from the survey, or import a pattern you created for a national file by clicking the 'Read IRRs' button.

The second tab in this editor (HIV age distribution) allows you to examine and change the ratios of incidence by age to the reference age group (25-29). In most cases you should accept the default pattern.

7.2.6.11 Results

Select the **Results** menu item to see a drop down menu with the categories of HIV/AIDS indicators. They are:

- Dashboard
- Total population
- Adults (15-49)
- Adult 15+
- Adults 50+
- Young people (15-24)
- Adolescents (10-19)
- Children (0-14)
- Children under 1
- Children 1-4
- Children under 2
- PMTCT
- ART
- Sub-populations
- AIDS impacts
- Orphans

Each category contains indicators that OneHealth can display. Choose one of these indicators, for example, **HIV+ population.** The following screen will appear:
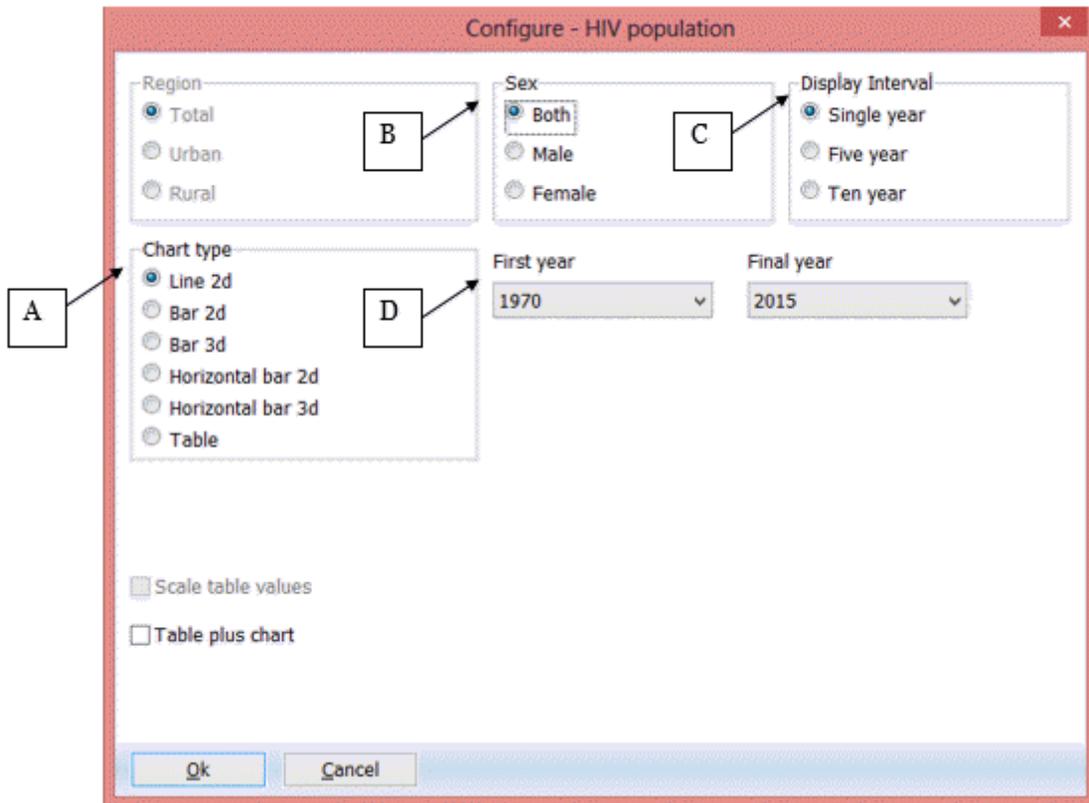
On this screen you can set the options for displaying the results.

    A.   **Chart type.** Select the type of chart you wish to display.

    B.   **Sex.** By default this is set to display both sexes, but you can change it to male or female only.

    C.   **Display interval.** By default this is set to display every year.

    D.   **First year** and **Final year.** By default this is set to the first and final year of your projection.

Once you have set the options, click **Ok** at the bottom of the screen. This will display a chart showing the indicator you have chosen, according to the variables you have selected on the previous screen. The following is an example of a line graph:
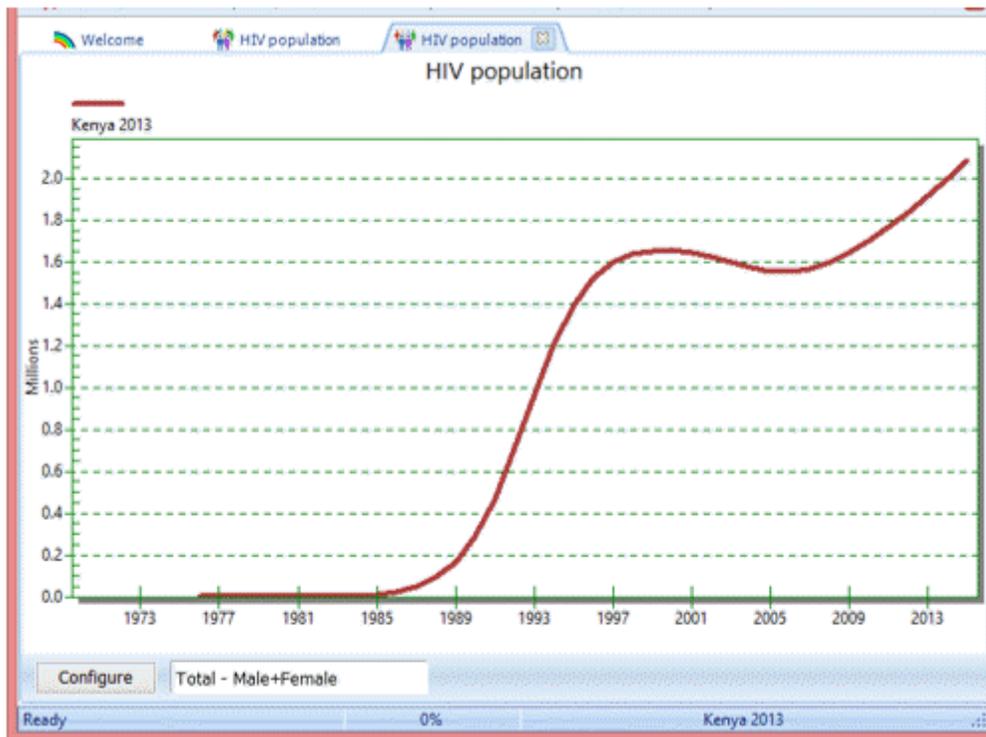
You can open up to 10 projections at one time and display the results in the same chart. The name of each projection that you open will appear at the bottom of the screen.

7.2.6.12 Save the projection

Save the projection by click the OneHealth menu button and selecting **Save** or **Save As** or by selecting **Home** and clicking the **Save** icon. .

7.2.6.13 Comparing projections

If you want to compare your new projection with a previous one you can open a projection as 'read only', Click on the 'File' menu in the upper left corner of the OneHealth window and select 'Read Only' then select the projection. You will now have two projections open in Spectrum. Any charts you display will show both the current and the comparison projection so that you can see what has changed. You can use the editors to see the inputs to the comparison projection but you will not be able to change anything. When OneHealth re-projects the current projection it will not re-project the comparison projection. This maintains the integrity of the previous projection and uses it only for comparison purposes.

7.2.6.14 Creating alternate projections

You can compare alternate projections by opening two or more files that have exactly the same inputs except for one indicator that you wish to examine. For example you might want to see the effect on AIDS deaths of increasing ART coverage. The easiest way to do this is to start by opening the base file. Then open the same file again. When you try to do this OneHealth will recognize that you are trying to open the same file twice. It will ask you if you want to go ahead and do this or if you want to rename the projection as you load it. If you choose to rename it, you can provide a new name, such as 'Expanded ART'. Then you will have two projections opens that are exactly the same. You can then edit the 'Expanded ART' projection and change the projected ART coverage. Then you can display the number of AIDS deaths to see the effect of expanded coverage.

When multiple projections are open OneHealth will display the names of the projections at the bottom of the screen and show an asterisk next to the active projection. This is the projection that will appear when you edit the data. To edit a different projection, click the **Set Active** button (when the **Modules** menu item is selected) and select the projection to edit.

7.2.6.15 Uncertainty analysis

OneHealth can calculate the range of plausible values for each of the output indicators. To use this feature you should open one, and only one, projection. If you have more than one projection open the uncertainty menu option will not appear.

To start an uncertainty analysis, select **Tools** from the main menu and then click the **Uncertainty Analysis** icon. You will see a display like the one below.

The column labeled '**s.d.**' shows the standard deviation (as a proportion of the mean value) used in the uncertainty analysis. You can change any of these standard values if you wish to try a larger or smaller range. The uncertainty analysis will randomly select parameter values for each of these indicators for each iteration.

By default the number of iterations is set to 300. It will take about 10 minutes to generate 300 runs. You can test the procedure by changing this to a smaller number but should generate 300 curves for your final analysis.

When you are ready to go, click the 'Process' button to start the analysis. When it is finished you can select any of the indicators to display the average curve and the 95% plausibility bounds. A summary

table, shown below, is available to display the ranges for all indicators for a selected year. Once you have run the uncertainty analysis then you will also see uncertainty bounds on most of the results from the 'Results' menu. If you make changes to any of your inputs after you have run the uncertainty analysis then it might be out-of-date. There is an indicator on the bottom of the Spectrum screen that will indicate if the uncertainty analysis is up-to-date (UA Valid) or out-of-date (UA Invalid).

2012	Lower 2.50%	Median 50%	Upper 97.50%
HIV Adults + Children	1,573,034	1,644,635	1,723,666
HIV Adults 15+	1,388,762	1,442,161	1,518,505
HIV 15+ female	786,737	821,162	864,361
HIV population- Children	176,267	202,474	233,846
Prevalence Adult	5.90	6.12	6.28
Prevalence- Males aged 15 to 24	1.28	1.59	2.11
Prevalence- Females aged 15 to 24	2.88	3.49	4.46
HIV Prevalence- Children	0.94	1.09	1.26
New HIV infections- Adult	82,475	87,360	98,187
New HIV infections- Children	7,195	10,126	13,691
Annual AIDS deaths	46,417	52,486	59,666
Annual AIDS deaths- Adult	36,977	41,625	48,833
Annual AIDS deaths- Children	8,712	10,861	13,570
Need for ART- Adult (15+)	622,589	643,536	669,368
Need for ART- Children	128,402	148,027	171,590
Mothers needing PMTCT	76,079	85,710	96,937
AIDS orphans	965,374	1,032,799	1,102,472
HIV population (15-49)	1,254,941	1,299,251	1,330,835
Number of new HIV infections	90,456	97,486	107,517
Incidence Adults 15-49	0.38	0.40	0.44
Annual AIDS deaths- Children (1-4)	1,897	2,538	3,350
HIV+ pregnant women with CD4 counts < 350	37,955	40,383	42,775
New HIV infections - Males aged 15 to 24	9,354	12,520	14,412
New HIV infections - Females aged 15 to 24	21,353	24,935	31,860

Close   Configure   2012

7.2.7   Methodology

7.2.7.1   Structure

The population is tracked over time by age, sex, HIV state and duration in that HIV state. The population array is defined as $pop_{a,t,s,h,d}$ where:

a = age (0..79, 80+, total)

s = sex (male, female, both)

t = time in years (1 = first year of projection)

h = HIV state

For children (0-14) the HIV states are:

> Neg: not infected
>
> Asym: HIV+, infected at birth
>
> BF_LT6: HIV+, infected 0-6 months after birth through breastfeeding
>
> BF_6to12: HIV+, infected 6-12 months after birth through breastfeeding
>
> BF_GT12: HIV+, infected 12+ moths after birth through breastfeeding
>
> OnART: HIV+ and on ART

For adults (15+) the HIV states are:

> Neg: not infected
>
> CD4_<50: HIV+, CD4 count < 50 cells/µl
>
> CD4_50-99: HIV+, CD4 count 50-99 cells/µl
>
> CD4_100-199: HIV+, CD4 count 100-199 cells/µl
>
> CD4_200-349: HIV+, CD4 count 200-349 cells/µl
>
> CD4_350-500: HIV+, CD4 count 350-500 cells/µl
>
> CD4_500+: HIV+, CD4 count > 500 cells/µl
>
> ART_<50: On ART, initiated with CD4 count < 50 cells/µl
>
> ART_50-99: On ART, initiated with CD4 count 50-99 cells/µl
>
> ART_100-199: On ART, initiated with CD4 count 100-199 cells/µl
>
> ART_200-349: On ART, initiated with CD4 count 200-349 cells/µl
>
> ART_350-500: On ART, initiated with CD4 count 350-500 cells/µl
>
> ART_500+: On ART, initiated with CD4 count > 500 cells/µl

d = duration (number of years in the HIV state), dAll refers to all durations. For adults duration is always 1 for those who are not infected and those not on ART. For those on ART there are three levels: 0-6 months, 7-12 months, and 12+ months.

Whenever a subscript is omitted it means that the variable refers to all categories. For example $P_{a,t,s,h,d}$ defines the population by each of the five characteristics, whereas $P_{a,t,s,h}$ refers to the population of age a, sex s, HIV state h at time t for all durations d and P_t refers to the total population of all ages, both sexes, all HIV states and all durations at time t.

7.2.7.2   Initializing the population

The base year population may be entered as single ages or by five year age groups. If it is entered by five year age groups then it is split into single ages using a modified Beers approach as described in the manual for DemProj. In the base year the entire population is assumed to be HIV-negative.

7.2.7.3 Progressing the population to the next year

The first step in the projection is to progress the population from the previous year to the current year including all processes not related to HIV: aging, non-AIDS mortality, migration and births. These calculations start with the second year of the projection and continue until the final year. Each population group progresses one year in age and one year longer duration in the current state. Each population group is also subjected to non-AIDS mortality according to the input non-AIDS life expectancy and the selected model life table. The non-AIDS mortality rate is applied equally to all HIV states and durations within a specific age and sex group. Migration is calculated as a proportion of the population in each category. Thus we assume that migrants, whether in- or out-migrants, are distributed by HIV state and duration in that state according to the distribution of the resident population. The migration rate (mr) is the average number of migrants during the year divided by the population at the beginning of the period.

7.2.7.3.1 Uninfected population

The population that is not infected is progressed subject to aging, non-AIDS mortality and migration.

$$P_{a,s,t,h,d} = P_{a-1,s,t-1,h,d-1} \times (sr_{a-1,a,t} + mr_{a,s,t} * [1 + sr_{a-1,a,t}]/2)$$

Where:

h = 0 (uninfected)

$sr_{a-1,a,t,s}$ = proportion of population of sex s at time t surviving from age $a-1$ to age a. The survival rates defined by country-specific life tables. In most cases these have been prepared by the United Nations Population Division. You may also use any of the nine model life tables built-into DemProj.

$mr_{a,s,t}$ = migration rate for age a and sex s at time t. This is expressed as a proportion of the resident population.

For the HIV-infected population the calculations are somewhat different.

7.2.7.3.2 Children 0-4

HIV+ children between the ages of 0 to 4 are followed by age and CD4 percent category (<5, 5_10, 11-15, 16-20, 21-25, 26-30, >30). HIV+ children not on ART are also classified by the timing of infection: perinatal, 0-6 months postnatal, 7-12 months postnatal and 12+ postnatal. Children on ART are classified by duration on treatment: 0-6 months, 7-12 months and 12+ months. For ages 1-4 a ( ), sex s ( ), CD4 category y ( ) and duration d ( )

$$P_{a,s,t,h,d} = P_{a-1,s,t-1,h,d-1} \times (sr_{a-1,a,t,s} + mr_{a,s,t} \times [1 + sr_{a-1,a,t,s}]/2)$$

HIV+ children between the ages of 5 to 14 are followed in a similar manner except they are classified by CD4 count category (<200, 200-349, 350-499, 500-749, 750-999, 1000+) rather than CD4 percent.

New HIV infections among children are distributed by CD4 percent according to data from the HIV Paediatric Prognostic Markers Collaborative Study (HPPMCS) and the Concerted Action on Sero-Conversion to AIDS Death in Europe (CASCADE) Collaboration (Dunn D, Woodburn P, Duong T, Peto J, Philips A, Gibb D et al. Current CD4 Cell Count and the Short-Term Risk of AIDS and Death before the Availability of Effective Antiretroviral Therapy in HIV-Infected Children and Adults, The Journal of Infectious Diseases 2008; 197:398–404). The default distribution of new child infections is: 60% to CD4

percent >30, 12% to CD4 percent 26-30, 10% to CD4 percent 21-25, 9% to CD4 percent 16-20, 5% to CD4 percent 11-15, 3% to CD4 percent 5-10 and 1% to CD4 percent <5.

When HIV+ children reach the age of 5 the are converted to CD4 count categories. The correspondence is based on an analysis of IeDEA data as reported in Stover et al., Updates to the Spectrum/AIM model for the UNAIDS 2020 HIV estimates, Journal of the International AIDS Society 2021, 24(S5):e25778

CD4 Count	CD4% <5	CD4% 5-10	CD4% 11-15	CD4 16-20	CD4% 21-25	CD4% 26-30	CD4% >30
<200	93.4%	33.9%	7.8%	3.2%	1.5%	1.3%	2.4%
200-349	5.0%	36.9%	25.4%	14.6%	5.8%	3.6%	1.9%
350-499	0.7%	16.7%	26.0%	24.7%	10.6%	9.5%	5.6%
500-749	0.6%	9.8%	27.8%	31.3%	36.5%	29.5%	10.7%
750-999	0.1%	1.8%	9.2%	16.8%	257%	22.3%	18.7%
1000+	0.1%	0.9%	3.8%	9.4%	19.9%	33.8%	60.7%

7.2.7.3.3 Children 15 years old

At age 15 children transition from the CD4 count categories associated with children 5-14 to the adult HIV states. Children are distributed by CD4 category according to the pattern shown in Table 8. These patterns were derived from the HIV Paediatric Prognostic Markers Collaborative Study (HPPMCS) which took place in western countries before ART was available. The study included a meta-analysis of individual longitudinal data on 3,941 HIV-1 infected children enrolled in cohort studies and randomized control trials in the USA and Europe. Care was taken to avoid using the same children in multiple studies.[1]

Table 8. Conversion of HIV+ children from CD4 count categories for ages 5-14 to adult categories

CD4 Category	<200	200-349	350-499	500-749	750-999	1000+
<50	44%					
50-99	21%					
100-199	35%					
200-249		33%				
250-349		67%				
350-500			100%			
>500				100%	100%	100%

[1] Dunn D. Short-term risk of disease progression in HIV-1-infected children receiving no antiretroviral therapy or zidovudine monotherapy: a meta-analysis. Lancet 2003;362(9396):1605-11.

7.2.7.3.4 Adults 15 to 79 years old

For most countries with concentrated epidemics some portion HIV infections is among people who inject drugs (PWID). In addition to the risks of HIV-related mortality PWID experience higher rates of non-HIV mortality compared to those who do not inject drugs. A review of mortality data found a crude non-AIDS mortality rate of about 2.5% among PWID.[1] AIM includes this excess mortality by adjusting the survival rate for all HIV+ adults by the proportion of the HIV+ population that is PWID and the excess mortality.

$$sr'_{a,t,s} = 1 - \{(1 - sr_{a,t,s}) + [0.025 - (1 - sr_{a,t,s})] \times PropPWID_t \times PropPWIDSex_s$$
$$/ (P_{a-1,t-1,s} / P_{a-1,t-1,BothSexes})\}$$

where:

$sr'_{a,t,s}$ = adjusted survival rate taking into account the excess mortality of PWID

0.025 = the crude non-AIDS mortality rate for PWID

$PropPWID_t$ = proportion of all HIV+ adults that are PWID

$PropPWIDSex_s$ = proportion of all PWID of sex s

If the population structure does not include designation of PWID (as is the case in most generalized epidemics) then no adjustment is made to the survival rate.

HIV-infected adults over the age of 15 are progressed by accounting for aging, non-AIDS mortality and migration occurring to people in each CD4 category.

For age a from 16 to 80, and all HIV states h and durations d:

$$P_{a,s,t,h,d} = P_{a-1,s,t-1,h,d-1} \times (sr'_{a-1,a,t,s} + mr_{a,s,t} \times [1 + sr'_{a-1,a,t,s}]/2)$$

For those who are not on ART, HIV status s varies from CD4 count <50 to >500. For those on ART HIV status s is the CD4 count category at ART initiation.

The number of non-AIDS deaths in each year is the population in the previous year multiplied by one minus the survival rate.

For all HIV states h and all durations d

$$D_{a,t,s} = pop_{a-1,t-1,s,h,d} * (1 - sr'_{a-1,a,t,s})$$
$$+ (mig_{a-1,t-1\ s} + mig_{a,t,s}) / 2 \times (1 - sr'_{a-1,a,t,s})$$

Where:
$D_{a,t,s}$ = deaths occurring from $a-1$ to a to the population of age a and sex s
$mig_{a,t,s}$ = number of migrants of age a and sex s in year t

[1] Mathers BD, Degenhardt L, Bucello C, Lemon J, Wiessing L, Hickman M. Mortality among people who inject drugs: a systematica review and meta-analysis

7.2.7.3.5 Adults 80+

For those aged 80+ the calculations include those aged 79 the previous year who age into the 80+ age group and those aged 80+ in the previous year who may remain in this age group or die.

$$P_{80+,t,s,h,d} = P_{79,t-1,s,h,d} \times (sr'_{79,80,t,s} + mr_{79,s,t} \times [1 + sr'_{79,80,t,s}]/2)$$
$$+ P_{80+,t-1,s,h,d} \times (sr'_{80+,80+,t,s} + mr_{80+,s,t} \times [1 + sr'_{80+,80+,t,s}]/2)$$

7.2.7.4 Births

The number of births is calculated from the number of women of reproductive age (15-49), the total fertility rate and the age distribution of fertility.

$$B_t = \Sigma_{a=15-49} P_{a,t,female} \times TFR_t \times ASFR_{a,t}$$

Where:

B_t = the number of births occurring in year t

$P_{a,t,female}$ = the number of women of age a at time t

TFR_t = the total fertility rate at time t

$ASFR_{a,t}$ = the percentage of life time births that occur to women of age a at time t

Total births are split into male and female births using the sex ratio at birth:

$$B_{male,t} = B_t \times SexRatio_t / (1 + SexRatio_t)$$

$$B_{female,t} = B_t \times 1 / (1 + SexRatio_t)$$

Where:

$B_{s,t}$ = births of sex s at time t

$SexRatio_t$ = the number of male births per 100 female births at time t

Women who are HIV+ have lower fertility than those who are not infected.[1] However, that does not affect the calculation of total births since this calculation is based on the TFR as measured by surveys, which would already include any depressing effect of HIV infection. The calculation of births to HIV+ women, described below, is adjusted to account for this effect.

The number of children younger than one is calculated from births, survival to the end of the year and migration. We use ½ the annual migration rate since only half of migrants in the youngest age group will still less than one year of age by the end of the time year. For the migrants we use 2/3 of the survival rate since, on average, they will subject to only ½ year of mortality, but mortality in the first six months of life is higher than during the second six months.

$$P_{0,t,s} = B_{s,t} \times (sr_{birth,0,t,s} + migr_{0,t,s}/2 \times (1 + 2 \times sr_{birth,0,t,s})/3$$

Deaths occurring to newborns are calculated in a similar fashion.

$$D_{0,t,s} = B_{s,t} * \{1 - sr'_{birth,0,t,s} + mig_{0,t-1\ s}/[2 \times (1 - sr'_{birth,0,t,s})/3]\}$$

[1] Chen WJ, Walker N. Fertility of HIV- infected women: insights from Demographic and Health Surveys *Sex Transm Infect* 2010 86: ii22-ii27

7.2.7.5 HIV+ adults not on ART

In each time step the HIV+ adults in each CD4 category may remain in that category, die from HIV-related causes, initiate ART or progress to the next lower CD4 category. Thus new exits from the CD4 category are calculated as:

$$X_{a,t,s,h} = P_{a,t-1,s,h} \times (\mu_{a,s,h} + \lambda_{a,h} + c_{a,s,h,t})$$

Where:

$X_{a,t,s,h}$ = number of HIV+ adults leaving the CD4 category h

$\mu_{a,s,h}$ = annual mortality rate of HIV+ adults of age a, sex s and CD4 category h

$\lambda_{a,h}$ = proportion of HIV+ adults progressing the next lower CD4 count category

$c_{a,s,h,t}$ = proportion of HIV+ adults initiating ART

New entrants are calculated as the number progressing from the next higher CD4 category. There will also be new infections entering into some CD4 categories but they are calculated later as described below.

$$N_{a,t,s,h} = P_{a,t-1,s,h+1} \times \lambda_{a,h}$$

Where:

$N_{a,t,s,h}$ = number of HIV+ adults entering the CD4 category h

$I_{a,s,t}$ = the number of new HIV infections among adults of age a and sex s at time t

$IP_{a,t,s,h}$ = the proportion of new infections starting in CD4 category h

The updated number of people in each category is calculated from the entrants and exits.

$$P_{a,t,s,h} = P_{a,t-1,s,h} + N_{a,t,s,h} - X_{a,t,s,h}$$

7.2.7.6 ART among adults

Need for ART is defined as all those currently on ART plus those eligible for treatment but not on it. Eligibility for adults is defined by CD4 count and membership in special populations (pregnant women, TB/HIV co-infected, sero-discordant couples, sex workers, MSM, PWID and other special populations).

For age a from 15 to 80

$$E_{a,s,t} = T_{a,s,t} + \Sigma_{h=<50,EL}\, P_{a,t,s,h,d} + \Sigma_{h=EL+1,>500}\, SP_{sp,t} \times SPE_{sp,t}$$

Where:

$E_{a,s,t}$ = Population eligible for treatment in year t

$T_{a,s,t}$ = Number on treatment at age a, sex s at time t

EL = CD4 count eligibility threshold

$SP_{sp,t}$ = Number of people in special population sp in year t

$SPE_{sp,t}$ = 1 if special population sp is eligible for treatment in year t, otherwise = 0.

Note that eligibility includes the total population $P_{a,t,s,h,d}$ for all CD4 categories less than or equal to the CD4 threshold for eligibility EL and any special populations SP for CD4 categories above the CD4 threshold for eligibility.

The number of HIV+ people in each eligible population except pregnant women is determined from the input on the percentage of all HIV+ adults that are members of each special population.

For HIV state h indicating CD4 count categories above the eligibility threshold:

$$SP_{sp,t} = SP\%_{sp} \times P_{t,s,h}$$

Where:

$SP\%_{sp}$ = the percentage of all HIV+ adults that are in special population sp

Note that this approach assumes that each special population is distributed by CD4 count the same as the total adult population.

For HIV+ pregnant women AIM calculates the number above the eligibility threshold based on the number of HIV+ women by age, the distribution of fertility by age and the effects of HIV infection on fertility.

$$PW_t = \Sigma_a\, P_{a,t,female,HIV+} \times TFR_t \times ASFR_{a,t} \times TFRred_a / [TFRred_a \times prev_{a,t} + (1 - prev_{a,t})]$$

Where

PW_t = the number of HIV+ pregnant women with CD4 counts above the eligibility threshold

TFR_t = total fertility rate

$\text{ASFR}_{a,t}$ = percentage of lifetime births occurring to women at age a

TFRred_a = ratio of TFR among HIV+ women to HIV- women of age a

$\text{prev}_{a,t}$ = proportion of women age a who are HIV+ and not on ART. Note: we assume that the fertility of women on ART is that same as uninfected women

The expression TFRred_a / [TFRred_a x $\text{prev}_{a,t}$ + (1 − $\text{prev}_{a,t}$)] converts the fertility reduction for HIV infection from a ratio of fertility among HIV+ to HIV- women to a ratio of fertility among HIV+ women to all women.

The number of adults on treatment is determined from the inputs, which may expressed as the number of men and women on treatment or the percentage of those eligible who are on treatment. If the inputs are percentages they are converted to numbers by multiplying by the number eligible for treatment.

The numbers (or percentages) of adults on ART are entered for December 31 of each year because that is the normal reporting date for programs reporting to WHO and UNAIDS. Most Spectrum calculations refer to July 1 so the inputs numbers need to be converted to July 1 by interpolation. The AIM calculations for adults are done in 1/10 year time steps. So for the first 5 time steps (from July 1 to Jan 1) the interpolation is between the data entered for t-1 to t and for the second 5 time steps (Jan 1 to July 1) the interpolation is between data entered for t to t+1. In other words, to calculate the number on treatment for October 2012 the model interpolates between entries for December 31, 2011 and December 31, 2012 and for March 2013 it interpolates between entries for December 31, 2012 and December 31, 2013. This interpolation established the number on treatment at any time t.

The number that need to start treatment at time t is the difference between the number on treatment and the number surviving on treatment from the previous time step.

$\text{NewT}_{a,t,s} = \text{NeedT}_{a,t,s} - \Sigma_d\ T_{a,t-1,,s,h,d} \times (1 - \alpha_{a,t,h,d})$

Where:

$\text{NewT}_{a,t,s}$ = number of adults of age a and sex s newly stating treatment at time t

$\text{NeedT}_{a,t,s}$ = number of adults of age a and sex s eligible for treatment at time t

$T_{a,t,s,h,d}$ = number of adults of age a and sex s who initiated treatment at CD4 category h who have been on treatment for duration d at time t. Note that duration is either 0-6 months, 7-12 months or 12+ months. CD4 categories are <50, 50-99, 100-199, 200-249, 250-349, 350-500. 500+.

$\alpha_{a,t,h,d}$ = mortality rate among adults of age a and sex s who initiated treatment at CD4 category h who are still on treatment at time t

New ART patients are distributed by CD4 count according to the average of two allocation schemes. The first scheme assumes that new patients are distributed according to the distribution of the number eligible for treatment but not on treatment.

$$P1_h = E'_h / \Sigma_h E'_h$$

Where:

$P1_h$ = proportion of new ART patients starting ART at CD4 category h under scheme 1

E'_h = number eligible for ART but not on ART at CD4 category h

The second scheme allocates new patients according to the expected number of deaths if no one starts ART.

$$P2_h = E_h \times \mu_h / \Sigma_h (E_h \times \mu_h)$$

Where:

$P2_h$ = proportion of new ART patients starting ART at CD4 category h under scheme 2

μ_h = mortality rate for HIV+ adults not on treatment with CD4 count h

The final allocation is the average of the two approaches.

$$P0_h = (P1_h + P2_h) / 2$$

New ART patients are distributed according to the final proportions:

$$NewT_{a,t,s,h} = NewT_{a,t,s} \times P0_h$$

These new patients are added to existing patients.

$$T_{a,t,s,h} = T_{a,t,s,h} + NewT_{a,t,s,h}$$

In each time step the number of people on ART by CD4 category at initiation may be increased by those newly initiating ART and decreased by death. ART patients are tracked by duration on treatment. Thus the calculations are done for three categories of ART patients: those on ART for 6 months or less $(d=1)$, those on ART for 7-12 months $(d=2)$ and those on ART for longer than 12 months $(d=3)$:

For those on treatment for 0-6 months

$$A_{a,t,s,h,1} = A_{a,t,s,h,1} \times (1 - \alpha_{a,s,h,1} - 12/6) / ts + NewT_{a,t,s,h}$$

Where:

$A_{a,t,s,h,1}$ = number on treatment

$\alpha_{a,s,h,1}$ = mortality rate of those on treatment for 0-6 months

ts = time step equal to 1/10 year

12/6 = adjustment to account for movement to the 7-12 month duration category

For those on treatment for 7-12 months

$$A_{a,t,s,h,2} = A_{a,t,s,h,2} \times (1 - \alpha_{a,s,h,2} - 12/6) / ts + A_{a,t,s,h,1} \times (12/6) / ts$$

For those on treatment 12+ months

$$A_{a,t,s,h,3} = A_{a,t,s,h,3} \times (1 - \alpha_{a,s,h,2}) / ts + A_{a,t,s,h,2} \times (12/6) / ts$$

7.2.7.7 New adult HIV infections

New adult HIV infections are calculated from HIV incidence among adults aged 15 to 49 provided by EPP. The incidence provided by EPP is defined calculated as:

<u>New Infection from July 1 year t to July 1 year t+1</u>

Susceptible population on July 1 2006

Since Spectrum is age and sex-structured (calculating by sex and single age) and EPP is not (calculating for all 15-49 and both sexes) when the incidence provided by EPP is used in Spectrum it may not exactly reproduce the prevalence trend fit by EPP. Therefore Spectrum adjusts the incidence each year in order to more closely match the EPP prevalence curve.

First we calculate the number of HIV+ adults 15-49 needed to match the prevalence specified by EPP.

$$NeededHIV_t = P_{15\text{-}49,t} \times p_t$$

Where

$NeededHIV_t$ = number of HIV+ adults 15-49 needed to match EPP prevalence

$P_{15\text{-}49,t}$ = number of adults 15-49

p_t = prevalence among adults 15-49 in year t from EPP

$$NeededNewHIV_t = NeededHIV_t - P_{15\text{-}49,t,\text{Both Sexes,HIV+}}$$

Where:

$NeededNewHIV_t$ = the number of new infections among adults 15-49 needed to match EPP prevalence

$P_{15\text{-}49,t,\text{Both Sexes,HIV+}}$ = the number of adults 15-49 of both sexes who are HIV+

The adjustment factor is the needed incidence (NeededNewHIV / (population – HIV population) divided by the incidence coming from EPP.

$$\text{AdjF}_t = [\text{NeededNewHIV}_t / (P_{15\text{-}49,t} - P_{15\text{-}49,t,\text{Both Sexes, HIV+}})] / \text{I\_EPP}_t$$

Where:

AdjF_t = incidence adjustment factor at time t

I_EPP_t = incidence provided by EPP in year t

The incidence adjustment factor is calculated for all historical years. The adjustment factor for the current year is used for all future years.

The incidence adjustment factor may be turned off by unchecking the 'EPP prevalence adjustment' in the 'Direct incidence input' editor. It should be turned on for most analyses but should be turned off when comparing two files with different historical inputs (such as difference levels of ART coverage).

In the approach currently used in EPP a smooth prevalence curve is fit to surveillance and survey data and then incidence is estimated from the prevalence curve. This approach works well to smooth annual fluctuations in surveillance data. However, when something happens that should cause a sharp change in prevalence, such as a sharp rise of fall in ART coverage, then this approach works less well, since it will still produce a smooth prevalence curve and the rapid changes will show up in the estimated incidence curve. To avoid these sharp changes in incidence from showing up in Spectrum output, we impose a limit on the size of the adjustment factor, usually 1.2, in order to smooth fluctuations in incidence.

The final incidence is the incidence from EPP multiplied by the adjustment factor.

$$I_t = \text{I\_EPP}_t \times \text{AdjF}_t$$

Incidence among males and females is determined from incidence among all adults 15-19 (I_t) and the sex ratio of incidence, which is an input. The sex ratio of incidence is defined a female incidence divided by male incidence.

$$I_{f,t} = I_t \times (P_{15\text{-}49,t,f} - P_{15\text{-}49,t,f,\text{HIV+}} + P_{15\text{-}49,t,m} - P_{15\text{-}49,t,m,\text{HIV+}})$$
$$/ [P_{15\text{-}49,t,f} - P_{15\text{-}49,t,f,\text{HIV+}} + (P_{15\text{-}49,t,m} - P_{15\text{-}49,t,m,\text{HIV+}}) / SR_t]$$

$$I_{m,t} = I_{f,t} / SR_t$$

Where:

$I_{f,t}$ = female incidence at time t

$I_{m,t}$ = male incidence at time t

SR_t = ratio of female to male incidence at time t

New male and female infections are calculated from incidence.

$$NI_{s,t} = I_{s,t} \times (P_{15\text{-}49,t,s} - P_{15\text{-}49,t,s,HIV+})$$

Where:

$NI_{s,t}$ = new infections among sex s at time t

New adult infections with in each sex are distributed by age according to the input pattern of incidence rate ratios. These patterns describe the ratio of incidence at any age to incidence in the 25-29 age group. Thus a ratio of 0.5 means that incidence at that age is half the incidence at age 25-29.

The first step is to calculate new infections if the incidence for the 25-29 age group is assumed to be 1.0. In that case the number of new infections would be simply the susceptible population multiplied by the incidence rate ratio for each age.

For all ages 15 to 80

$$I1_{s,t} = \Sigma_a \, P_{a,t,s,HIV\text{-}} \times IRR_{a,t,s}$$

Where:

$I1_{s,t}$ = New infections is incidence among 25-29 is assumed to be 1.0

$P_{a,t,s,HIV\text{-}}$ = uninfected population of age a and sex s at time t

$IRR_{a,t,s}$ = incidence rate ratio for age a and sex s at time t

Then an adjustment factor is calculated as the ratio of the total number of new infections required divided by the number new infections when incidence among 25-29 is assumed to be 1.0

$$IAF_{s,t} = NI_{s,t} / I1_{s,t}$$

Where:

$IAF_{s,t}$ = incidence adjustment factor for sex s at time t

New infections at each age are calculated from the EPP incidence, the adjustment factor and the incidence rate ratio for that age.

For all ages a from 15 to 80

$$NI_{a,t,s} = P_{a,t,s,HIV\text{-}} \times I_{s,t} \times IAF_{s,t} \times IRR_{a,t,s}$$

Note that this final calculation includes all ages up to age 80. Thus the pattern of incidence rate ratios specifies the new infections occurring to adults above the age of 49.

Finally, new adult infections are added to the appropriate population.

$$P_{a,t,s,h} = P_{a,t,s,h} + NI_{a,t,s} \times IP_{a,t,s,h}$$

Where:

$IP_{a,t,s,h}$ = the proportion of new infections starting in CD4 category h

7.2.7.8 Births to HIV+ women

The number of HIV+ births is calculated from total births, the prevalence among pregnant women and the transmission rate.

Births to HIV+ women are calculated in a similar manner to the calculation of all births. The number of HIV+ women in each age group is multiplied by the total fertility rate and by the proportion of life time births that occur in that age group. The fertility of HIV+ women is adjusted for the effects of HIV infection on fertility as described in Chapter 4.

For age a from 15 to 49

$$PW_t = \Sigma_a\, P_{a,t,f,HIV+} \times TFR_t \times ASFR_{a,t} \times TFRred_a / [TFRred_a \times prev_{a,t} + (1 - prev_{a,t})]$$

Where:

PW_t = the number of HIV+ pregnant women with CD4 counts above the eligibility threshold

TFR_t = total fertility rate

$ASFR_{a,t}$ = percentage of lifetime births occurring to women at age a

$TFRred_a$ = ratio of TFR among HIV+ women to HIV- women of age a

$prev_{a,t}$ = proportion of women age a who are HIV+ and not on ART. Note: we assume that the fertility of women on ART is that same as uninfected women

The expression $TFRred_a / [TFRred_a \times prev_{a,t} + (1 - prev_{a,t})]$ converts the fertility reduction for HIV infection from a ratio of fertility among HIV+ to HIV- women to a ratio of fertility among HIV+ women to all women.

In some countries some women who know that they are HIV-infected may elect an abortion to avoid the chance of transmitting the infection to their newborn child. The number of births to HIV+ mothers is reduced by the proportion of pregnancies terminated by abortion.

$$B_{HIV+,t} = PW_t \times (1 - AbortionRate_t)$$

Where:

$B_{HIV+,t}$ = births occurring to HIV+ women at time t

Abortion Rate$_t$ = the proportion of pregnancies occurring to HIV+ women that are terminated by abortion

Note that the number of births to HIV+ women is different from the number of HIV+ pregnant women. About 15% of pregnancies do not result in a live birth due to miscarriage, spontaneous abortion and still births.[1] However, most of these miscarriages occur early in the pregnancy, often before a woman knows she is pregnant. Most services for HIV+ pregnant women are provided later in the pregnancy. So we do not adjust for miscarriage.

The need for prophylaxis to prevent mother-to-child transmission (PMTCT) is defined as the number of HIV+ women giving birth.

[1] Nybo Anderson AM, Wohlfarht J, Christens P, Olsen Jorn, Melbye M (2000) Maternal age and fetal loss: population based register linkage study BMJ 2000;320;1708-1712.

7.2.7.9   Mother-to-child transmission

The transmission of HIV from mother to child is divided into two components: transmission during gestation and delivery and postnatal transmission through breastfeeding. The perinatal mother-to-child transmission rate is the weighted average of the proportion in each prophylaxis group and the corresponding probability of transmission. The prophylaxis groups are:

- No prophylaxis, CD4 count < 200 cells/μl
- No prophylaxis, CD4 count 200-350 cells/μl
- No prophylaxis, CD4 count >350 cells/μl
- Incident infection
- Single dose Neviripine
- Dual ARVs
- Option A
- Option B
- Option B+: ART started before current pregnancy
- Option B+: ART started during current pregnancy more than 4 weeks before delivery
- Option B+: ART started during current pregnancy less than 4 weeks before delivery

The transmission probabilities are as defined in Table 1 in Chapter 4.

$$PTR_t = \sum_c Prophylaxis_{c,t} \times TR_c$$

Where:

PTR_t = perinatal transmission rate

$Prophylaxis_{c,t}$ = the proportion of women by prophylaxis category

TR_c = probability of transmission of HIV by prophylaxis category

The distribution of women not receiving prophylaxis by CD4 count is assumed to be the same as for all HIV+ women 15-49 not on ART.

The proportion of women with an incidence infection is assumed to be the same as all the incidence rate for all women 15-49.

In general we assume that women receiving Option A or Option B have CD4 counts greater than 350 cells/µl, otherwise they should be receiving ART. However, if the number of women receiving Option A and/or Option B exceeds the number of pregnant women with CD4 counts > 350 cells/µl then we assume that the excess represents women with CD4 counts < 35 cells/µl. We assume that the transmission rate for these women is double the rates when CD4 counts are > 350 cells/µl. In this case the transmission rate for all women receiving Option A or Option B is increased by multiplying by 1 + ExcessRatio, where the ExcessRatio is the proportion of HIV+ pregnant women receiving Option A or Option B divided by the proportion of HIV+ pregnant women with CD4 counts > 350 cells/µl.

The number of HIV+ births is equal to the number of births to HIV+ women multiplied by the perinatal transmission rate.

$$B_{HIV+,t} = B_{HIV+,t} \times PTR_t$$

These births are added to the HIV+ population of age 0.

$$P_{0,t,s,PTR} = B_{HIV+,t} \times SRB_s$$

Where:

$P_{0,t,s,PTR}$ = Population at age 0 infected perinatlly (PTR)

SRB_s = proportion of births that are of sex

HIV transmission from mother to child also may occur through breastfeeding. The number of children infected through breastfeeding is calculated as the product of the number of children born to HIV+ mothers who were not infected perinatally, the proportion of children exposed to transmission through breastfeeding, the monthly probability of transmission through breastfeeding and the duration of breastfeeding.

The distribution of women by type of feeding is an input. The distribution of women may be different for those exposed to the PMTCT program and those not exposed to it and may change over time. The overall distribution is a weighted average of the distributions for women exposed to the program and those not exposed.

Women using Option A or Option B at the start of breastfeeding, may not continue on prophylaxis for the entire breastfeeding period. The proportion still on Option A or Option B is calculated by month from the monthly dropout rate.

$OptA_{0,t}$ = input percentage of breastfeeding women using Option A

$Opt\_A_{m,t} = Opt\_A_{m-1,t} \times e^{m \times 2 \times \ln(1 + OptA\_DOt)}$

$OptB_{0,t}$ = input percentage of breastfeeding women using Option B

$Opt\_B_{m,t} = Opt\_B_{m-1,t} \times e^{m \times 2 \times \ln(1 + OptB\_DOt)}$

Where:

$OptA_{0,t}$ = Percentage of mothers using Option A at start of breastfeeding

$OptA_{m,t}$ = Percentage of mothers using Option A in month m

m = age of child in months

$OptA\_DO$ = monthly rate of drop out from prophylaxis

For each month m from birth to 36 months, the number of new infections through breastfeeding is calculated as:

$No\_prophylaxis_{m,t} = 1 - OptA_{m.t} - OptB_{m,t} - ARTbefore_t - ARTRduring_t$

$BFTR_{m,t} = No\_prophylaxis_{m,t} \times [PropLT350 \times TR_{LT350} + (1 - PropLT350) \times TR_{GT350} + PropInc_t \times TR_{incident}] + OptA_{m,t} \times TR_{OptA} + OptB_{m,t} \times TR_{OptB} + ARTbefore_t \times TR_{ARTbefore} + ARTcurrent_t \times TR_{ARTcurrent}$

Where:

$BFTR_{m,t}$ = breastfeeding transmission rate at month m

$PropLT350$ = proportion of HIV+ pregnant women with CD4 counts < 350

TR = monthly transmission rate

$PropInc_t$ = incidence among HIV+ pregnant women

The number of new infections is the number of exposed children (HIV-negative children born to HIV+ mothers who are still breastfeeding) multiplied by the transmission rate.

$NI_{m,t} = (B_{HIV+,t} - \Sigma_{m1=0 \text{ to } m-1} NI_{m1,t}) \times PropBF_{m,t} \times BFTR_{m,t}$

Where:

$NI_{m,t}$ = new infections occurring through breastfeeding in month m to children born in year t

$PropBF_{m,t}$ = proportion of children born in year t who are still breastfeeding at age m months

7.2.7.10 ART for children

Eligibility for ART for children may be defined as all HIV+ children below a specific age or those with CD4 counts or CD4 percents below a certain threshold.

The number of children on ART is defined directly by the inputs if they are provided in terms of the number of children on ART or calculated from need if the inputs are provided as coverage of those eligible for ART.

The number of children newly starting on ART is calculated as the difference between the total number that should be on ART (from the inputs converted from December 31 to July 1) minus those surviving on ART from the previous year.

$$NewART_t = (OnART_t - OnART_{t-1}) / 2 - \Sigma_{a=0,14} \, P_{a,t,ART}$$

New child ART patients are distributed by age and sex according to unmet need data provided by the IeDEA Consortium. The patterns differ by region and are shown n the Advanced Options editor under Pediatric Transition parameters - ART initiation by age.

The survival of children on ART is also determined by data provided by the IeDEA Consortium. Mortality rates are specified by age group (0, 1-2, 3-4, 5-9, 10-14), sex, duration on treatment (0-6 months, 7-12 months, 12+ months) and region (Asia, Central Africa, Developed Countries, East Africa, Eastern Europe, Latin America and the Caribbean, North Africa and Middle East, Southern Africa and West Africa). These patterns are shown in the Advanced Options editor under Pediatric transition parameters - HIV mortality with ART.

In each time step the number of people on ART by CD4 category at initiation may be increased by those newly initiating ART and decreased by death. ART patients are tracked by duration on treatment. Thus the calculations are done for three categories of ART patients: those on ART for 6 months or less *(d=1)*, those on ART for 7-12 months *(d=2)* and those on ART for longer than 12 months *(d=3)*:

For those on treatment for 0-6 months

$$A_{a,t,s,h,1} = A_{a,t,s,h,1} \times (1 - \alpha_{a,s,h,1} - 12/6) / ts + NewT_{a,t,s,h}$$

Where:

$A_{a,t,s,h,1}$ = number on treatment

$\alpha_{a,s,h,1}$ = mortality rate of those on treatment for 0-6 months

ts = time step equal to 1/10 year

12/6 = adjustment to account for movement to the 7-12 month duration category

For those on treatment for 7-12 months

$$A_{a,t,s,h,2} = A_{a,t,s,h,2} \times (1 - \alpha_{a,s,h,2} - 12/6) / ts + A_{a,t,s,h,1} \times (12/6) / ts$$

For those on treatment 12+ months

$$A_{a,t,s,h,3} = A_{a,t,s,h,3} \times (1 - \alpha_{a,s,h,2}) / ts + A_{a,t,s,h,2} \times (12/6)/ ts$$

7.2.7.11 Cotrimoxazole for children

Children are assumed to need cotrimoxazole under the following conditions:

- Less than 18 months of age, born to an HIV+ mother with unknown HIV status because PCR is not available
- HIV+ and under the age of five
- Age 5 and older and in need of treatment

For children less than 18 months of age the need for cotrimoxazole is all children born to HIV+ mothers. The totals are inflated to 18 months by multiplying by 1.5.

$$NeedCTX_t = PW_t \times 1.5 + \Sigma_{a=18months\ to\ 4\ years}\ P_{a,t,HIV+} + + \Sigma_{a=5-14}\ P_{a,t,NeedART}$$

The number of children receiving cotrimoxazole may be a direct input or may be calculated from the input coverage.

7.2.7.12 Child AIDS mortality

Children who are HIV+ and in need of ART but are not receiving either ART or cotrimoxazole progress to AIDS death according to the mortality schedules shown in Figure 6. For children on ART or cotrimoxazole or both the mortality rate is reduced by according to the input rates as described in Chapter 4.

For HIV+ children not on ART:

$$\mu_{p'd} = \mu'_{p'd} \times (1 + \%Ctx \times CtxRed_d)$$

where:

$\mu'_{p'd+}$ = mortality rate for children infectd at age p and d years ago not on cotrimoxazole

$\mu_{p'd}$ = mortality rate adjusted for cotrimoxazole use

$\%Ctx$ = percent of children on cotrimoxazole

$CtxRed_d$ = reduction in mortality among children receiving cotrimoxazole for d years.

For children receiving ART:

$$\mu_{p'd} = \mu'_{p'd} \times ARTRed_d \times (1 + \%Ctx \times CtxARTRed_d)$$

where

ARTRed$_d$ = reduction in mortality for children on ART for d years

CtxARTred$_d$ = reduction in mortality for children on both ART and cotrimoxazole)

The child population in any state is reduced by mortality

$$P_{a,t,s,p,d} = P_{a,t,s,p,d-1} \times (1 - \mu_{p'd})$$

Where:

p = indicates the timing of infection: perinatal, at 0-6 months, 7-12 months, 12+ months

d = time since infection, in years

$\mu_{p'd}$ = mortality rate for children infected at age p and d years ago

7.2.7.13 Orphans

The orphan calculations estimate the number of surviving children of adults who die from AIDS or other causes. The program calculates the expected number of children that were born to an adult before his or her death, and estimates how many are still alive and their age. The same approach is used for AIDS and non-AIDS orphans and for maternal and paternal orphans. For dual AIDS orphans the program uses a regression equation to estimate the proportion of children who are likely to have both parents die from AIDS given that one parent has died. The initial methodology was developed by Timeaus and Grassly and was updated in 2012 to incorporate PMTCT and ART dynamics.

We define a maternal (paternal) orphan as a child of age 0 to 17 years who has lost his/her mother (father) and consider the child a double orphan if he/she has lost both parents. Maternal and paternal orphans are inclusive of double orphans. To analyze the impact of the HIV-infection on the number of orphans, we estimated number of AIDS and non-AIDS orphans as surviving children of adults who, at the time of death, were HIV-infected and uninfected, respectively.

7.2.7.13.1 Maternal non-AIDS orphans

Each year (t), age-based estimates of number of deaths in uninfected women and their fertility rates in the past 17 years were used to calculate the number of children born to those women during that time period. Using survival rates of children when uninfected, maternal non-AIDS orphans, Ω_t, were estimated using the equation

$$\Omega_t = \sum_{\hat{a}=15}^{a^f+17} \sum_{\substack{\hat{a}-c \\ =\min(\hat{a},a^f)}}^{\max(15,\hat{a}-17)} D_{t,\hat{a}} f_{t-c,\hat{a}-c} s_{t,c}$$

where, $\hat{a}$ is the mother's age at death, a^f is the maximum fertility age for women, c is the age of child at time t, $D_{t,a}$ are the number of deaths at time t in women of age a, $f_{t,a}$ are the fertility rates at time t in women of age a, and $s_{t,a}$ is the cumulative survival probability to age a at time t (for children of both sex).

7.2.7.13.2 Maternal AIDS orphans

Ω

Women infected with HIV have a reduced rate of fertility when not on treatment with antiretroviral therapy (ART). Therefore, in addition to the variables used in non-AIDS orphans, estimating the number of AIDS orphans requires the additional knowledge of the age of the mother at the time of acquisition of HIV and at the time of ART initiation.

To estimate the age at infection for women not on ART we first generate a lookup age-matrix of constant values (M) with rows representing age a and columns representing CD4 count category i (=1 (highest) to the lowest CD4 cell count categories), such that, for a woman not on ART and at age $\hat{a}$ and CD4 category i at death, if matrix element $m(a,i)$ equals $\hat{a}$ then age at infection $h_{\hat{a},i} = a$. To generate such a matrix we assumed exponentially distributed rates of transition μ_i from CD4 count category i to $i+1$, and estimated matrix element $m(a,i)$ as the average age of a person in CD4 count category i given age at infection equals a. That is,

$$m(a, i) = a + \sum_{k=1}^{n}(x_1 + x_2 + .. x_i)/n,$$

Where x_j are instances of random variables $x_j \sim exp(\mu_j)$ and n is a large number so as to obtain an average duration of a large enough sample (we assumed $n = 1000$).

Age at infection for women on ART can also be estimated using matrix M if age at ART initiation is known. To estimate age at ART initiation we generated a constant duration-matrix L such that the element $l(t,i)$ represent the average duration on ART at year t for women starting ART at CD4 count category i, i.e.,

$$l(t, i) = \left\{ \sum_{j=0}^{t} \sum_{\forall a} N''_{j,a,i} - \left[\prod_{j=0}^{t} \left(\sum_{\forall a} D''_{j,a,i} \right) \left(\sum_{\forall a} N''_{j,a,i} \right) \right] \right\} \Big/ \sum_{\forall a} N''_{t,a,i}$$

where $N''_{t,a,I}$ and $D''_{t,a,I}$ are the number of surviving persons on ART and number of deaths, respectively, at year t among women of age a and CD4 count category at ART initiation of i. For women with age $\hat{a}$ at death, we approximate age at ART initiation $A_{t,\hat{a},i} = \hat{a} - l(t,i)$ and, given matrix element $m(a,i) = \hat{a} - l(t,i)$ approximate age at infection $h_{\hat{a},i} = a$.

The number of AIDS-orphans for a woman at age $\hat{a}$ at death and CD4 count category i (at death, if the woman was not on ART, and at ART initiation, if the woman was on ART) can be estimated as the sum of surviving children born before infection $(n'_{t,\hat{a},i})$, during infection when not on ART $(n''_{t,\hat{a},i})$, and, if the woman was on ART, during infection when on ART $(n'''_{t,a,i})$, using,

$$\Omega_{t,\hat{a},i} = \sum_{\substack{\hat{a}-c \\ =max\,(a^h,\hat{a}-17)}}^{max\,(15,\hat{a}-17)} f_{t-c,\hat{a}-c} s_{t,c},$$

$$\Omega'_{t,\hat{a},i} = \sum_{\substack{\hat{a}-c \\ =max\,(a^A,\hat{a}-17)}}^{max\,(a^h,\hat{a}-17)} f_{t-c,\hat{a}-c} r_{\hat{a}-c}(p_{t,c} s'_{t,c} + (1-p_{t,c})s_{t,c}), \text{ and}$$

$$\Omega''_{t,\hat{a},i} = \sum_{\substack{\hat{a}-c \\ =min\,(\hat{a},a^f)}}^{max\,(a^A,\hat{a}-17)} f_{t-c,\hat{a}-c}(p_{t,c} s'_{t,c} + (1-p_{t,c})s_{t,c}),$$

where, for notational clarity $v^A_{t,\hat{a},I}$ and $v^h_{\hat{a},I}$ were written as v^A and as v^h, respectively, v_a is the relative reduction in the fertility rate due to HIV-infection in women at age, $p_{t,c}$ are probability values that a child of age at time had acquired HIV from vertical transmission from mother, and d_c are the probability values that a child infected through vertical transmission survives to age . Since children can be infected at birth (perinatal) or during breastfeeding we approximate

$$p_{t,c} = \frac{\sum_{j=0}^{min\,(c,2)} N_{t-c+j,j}}{\sum_{\forall a}\sum_{\forall i} B'_{t-c,a,i} + B''_{t-c,a,i}} \text{ and } s'_c = \frac{\sum_{\forall i}(N'_{t,c,i} + N''_{t,c,i})}{\sum_{j=0}^{min\,(c,2)} N_{t-c+j,j}},$$

where $N_{t,a}$ are the number of newly infected children of age at time infected through vertical transmission, $B'_{t,a,i}$ are the number of births at time to HIV-infected women at age , CD4 count category and not on treatment at time, $B''_{t,a,i}$ are the number of births at time to HIV-infected women at age , CD4 count category and on treatment at time, $N'_{t,c,i}$ are the number of surviving HIV-infected persons of age at time , CD4 count category , and not on treatment, and $N''_{t,c,i}$ are the number of surviving HIV-infected persons of age at time , CD4 count category , and on treatment.

The total number of new AIDS orphans from all women dying at time was estimated as

$$\sum_{\hat{a}=15}^{a^f+17} \sum_{\forall i} \left\{ \left(D'_{t,\hat{a},i} + D''_{t,\hat{a},i} \right) \left(\Omega_{t,\hat{a},i} + \Omega'_{t,\hat{a},i} \right) + D''_{t,\hat{a},i} \Omega''_{t,\hat{a},i} \right\},$$

where $D'_{t,\hat{a},i}$ are the number of deaths at time in women of age , at CD4 count category , and not on ART, and $D''_{t,\hat{a},i}$ are the number of deaths at time in women of age with CD4 count category at ART initiation. A schematic view of the different time periods has been presented in Figure 1.

7.2.7.13.3 Paternal non-AIDS orphans

The number of surviving children born to uninfected men who died in year t ($\bar{\Omega}_t$), i.e., non-AIDS orphans, were calculated using estimates of fertility rates of those men in the past 17 years and also the HIV-status of the mother at the time of birth as it affects the fertility rate of the mother and survival of the child due to chances of vertical transmission, as,

$$\bar{\Omega}_t = \sum_{\hat{a}=15}^{\bar{a}^f+17} \sum_{a^{\hat{d}-c}=\min(\hat{a},\bar{a}^f)}^{\max(15,\hat{a}-17)} \bar{D}_{t,\hat{a}} \bar{f}_{t-c,\hat{a}-c} \{ P_{t-c}(w^-|m^-)s_{t,c}$$

$$+ P_{t-c}(w^+|m^-)k_{t-c}[(1-p_{t,c})s_{t,c} + p_{t,c}s'_{t,c}]\},$$

where $\hat{a}$, is the father's age at death, $\bar{a}^f$ is the maximum fertility age for men, c, is the age of child at time t, $\bar{D}_{t,a}$ are the number of deaths at time t in men of age a, $\bar{f}_{t,a}$ are the fertility rates at time t in men of age a, $s_{t,a}$ are the probabilities of survival to age a at time t (for children of both sex), $P_t(w^-|m^-)$ and $P_t(w^+|m^-)$ are the conditional probabilities that the mother was not infected and infected, respectively, given that the father was not infected at time t, k_t are the relative reduction in fertility due to HIV-infection in women at time t, $p_{t,c}$ are probability values that a child of age c at time t had acquired HIV from vertical transmission from mother, and d_c are the probability values that a child infected through vertical transmission survives to age c (for children of both sex). We use the method proposed by Grassly and Timaeus, 2005[1], to determine the HIV-status of the mother given the HIV-status of the father at time of birth as $P_t(w^+|m^-) = \{P_t(w^+) - P_t(w^+|m^+)P_t(m^+)\} / \{1 - P_t(m^+)\}$, where, $P_t(w^+)$ and $P_t(m^+)$ are the prevalence of HIV among women (and men) in partnerships at time t and whose values were approximated by adult prevalence of HIV in women (and men), and $P_t(w^+|m^-)$ was obtained through logistics regression with dependent factor as the HIV-prevalence ($P'_t(w^+)$) in women tested in antenatal clinics as $P_t(w^+|m^-) = \{exp[-0.84+9.1P'_t(w^+)]\} / \{1 + exp[-0.84+9.1P'_t(w^+)]\}$. Assuming HIV-infected women have a reduced rate of fertility when not on ART, k_t was estimated as $\{\Sigma^{af}_{a=15}\Sigma_{vi}(r_a N'_{t,a,i}+N''_{t,a,i})\} / \{\Sigma^{af}_{a=15}\Sigma_{vi}(N'_{t,a,i}+N''_{t,a,i})\}$, where the approximation over all ages was performed because it is difficult to predict the age of the mother.

[1]Grassly, N.C. and I.M. Timaeus, Methods to estimate the number of orphans as a result of AIDS and other causes in Sub-Saharan Africa. *J Acquir Immune Defic Syndr*, 2005. 39(3): p. 365-75.

7.2.7.13.4 Paternal AIDS orphans

Similar to the method in maternal AIDS orphans, the total number of paternal AIDS orphans were estimated as,

Ω

$$\sum_{\hat{a}=15}^{\bar{a}^f+17} \sum_{\forall i}\left\{\left(\bar{D}'_{t,\hat{a},i} + \bar{D}''_{t,\hat{a},i}\right)\left(\bar{\Omega}_{t,\hat{a},i} + \bar{\Omega}'_{t,\hat{a},i}\right) + \bar{D}''_{t,\hat{a},i}\bar{\Omega}''_{t,\hat{a},i}\right\}, \text{ with}$$

$$\bar{\Omega}_{t,\hat{a},i} = \sum_{\hat{a}-c=\max(a^h,\hat{a}-17)}^{\max(15,\hat{a}-17)} \bar{f}_{t-c,\hat{a}-c}\{P_{t-c}(w^-|m^-)s_{t,c} + P_{t-c}(w^+|m^-)k_{t-c}[(1-p_{t,c})s_{t,c} + p_{t,c}s'_{t,c}]\},$$

$$\bar{\Omega}'_{t,\hat{a},i} = \sum_{\hat{a}-c=\max(a^A,\hat{a}-17)}^{\max(a^h,\hat{a}-17)} \bar{f}_{t-c,\hat{a}-c}\{P_{t-c}(w^-|m^+)s_{t,c} + P_{t-c}(w^+|m^+)k_{t-c}[(1-p_{t,c})s_{t,c} + p_{t,c}s'_{t,c}]\}, \&$$

$$\bar{\Omega}''_{t,\hat{a},i} = \sum_{\hat{a}-c=\min(\hat{a},\bar{a}^f)}^{\max(a^A,\hat{a}-17)} \bar{f}_{t-c,\hat{a}-c}\{P_{t-c}(w^-|m^+)s_{t,c} + P_{t-c}(w^+|m^+)k_{t-c}[(1-p_{t,c})s_{t,c} + p_{t,c}s'_{t,c}]\},$$

where, $\bar{\Omega}_{t,\hat{a},i}$, $\bar{\Omega}'_{t,\hat{a},i}$, and $\bar{\Omega}''_{t,\hat{a},i}$ are the surviving children born to men before they were infected, during infection when not on ART, and, for men on ART, during infection when on ART, respectively, $\bar{D}'_{t,\hat{a},i}$ are the number of deaths at time t in men of age $\hat{a}$, at CD4 count category i, and not on ART, and $\bar{D}_{t,\hat{a},I}$ are the number of deaths at time t in men of age $\hat{a}$ with CD4 count category i at ART initiation. As in maternal AIDS orphans, a^h and a^A represent $\hat{a}_{t,\hat{a},i}$ (age at infection) and $a^h_{\hat{a},i}$ (age at ART initiation), respectively, and were estimated as in the case of women.

7.2.7.13.5 Double orphans

We estimate double orphans using the regression method first proposed in Grassly and Timaeus[1] and later updated[2,3] where risk of double orphanhood of children at age a at time t ($\lambda_{t,a}$) were estimated as correlates of age a, adult (women and men) HIV-prevalence at two points in time, and risk of double orphanhood if risk of maternal or paternal orphanhood were independent of each other ($\tilde{\lambda}_{t,a}$) as,

$$ln\lambda_{t,a} = \theta_0 + \theta_1 \, ln\tilde{\lambda}_{t,a} + \theta_2 a + \theta_3 lnP_{t-1}((w+m)^+) + \theta_4 a \, lnP_{t-1}((w+m)^+)$$
$$+ \theta_5 lnP_{t-12}((w+m)^+) + v_k + u_t + \gamma$$

where, θ are the coefficient values of the dependent variables, v_k and u_t are normally distributed random intercept terms that indicate the degree to which the excess risk of dual orphanhood varies between countries (k) and over time (t) within countries, and γ is a residual term.

Figure 12. Schematic representation of surviving orphans born during different time periods of mother's life based on HIV-status of mother at the time of death
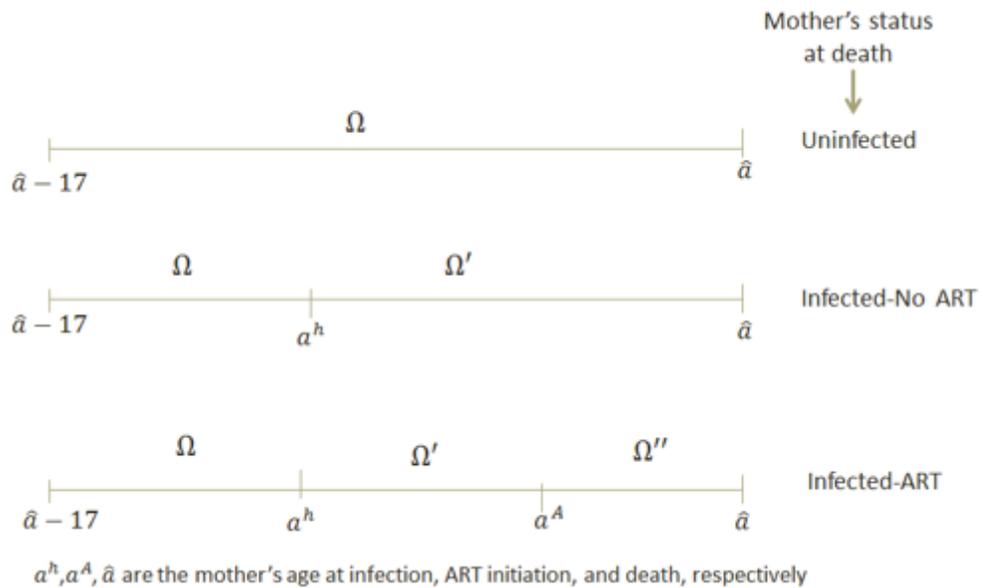
Mother's status
at death
↓

$$\Omega$$

Uninfected

$\hat{a} - 17$ $\hat{a}$

$$\Omega \qquad \Omega'$$

Infected-No ART

$\hat{a} - 17$ a^h $\hat{a}$

$$\Omega \qquad \Omega' \qquad \Omega''$$

Infected-ART

$\hat{a} - 17$ a^h a^A $\hat{a}$

$a^h, a^A, \hat{a}$ are the mother's age at infection, ART initiation, and death, respectively

[1] Grassly, N.C. and I.M. Timaeus, Methods to estimate the number of orphans as a result of AIDS and other causes in Sub-Saharan Africa. *Acquir Immune Defic Syndr*, 2005. 39(3): p. 365-75.

[2] Stover, J., et al., The Spectrum projection package: improvements in estimating incidence by age and sex, mother-to-child transmission, HIV progression in children and double orphans. Sex Transm Infect, 2010. 86 Suppl 2: p. ii16-21.

[3] Timaeus, I.M., Estimation and progression of dual orphans in populations with generalized HIV epidemics: Updated methods, Report to UNAIDS, 2008.

7.3   FamPlan

7.3.1   What is FamPlan?

In the past several decades, more and more governments have become conscious of the importance of population and fertility as a key factor in human rights, the health of mothers and children, and social and economic development. Most developing countries now have population policies and programs and consider population in their national development plans. The 1994 International Conference on Population and Development (ICPD) held in Cairo encouraged all countries to adopt goals of meeting the reproductive health needs of their populations within the next few decades. Thus, it becomes increasingly important to (1) ensure that the adopted goals and timetables are feasible and (2) determine the requirements for achieving the goals. Only then will the goals be effectively used in development planning and the implementation of expanded family planning programs.

In 1986, The Population Council and The Futures Group developed the Target-Setting Model (Bongaarts and Stover, 1986). This model determined the family planning requirements to meet specific fertility goals. It could be used to determine the number of family planning users, new acceptors, and commodities required by method and source to achieve a total fertility rate (TFR) goal given estimates of changes in the other proximate determinants of fertility (i.e., the proportion of women of reproductive age in union, postpartum infecundability, etc.; see Chapter III). Researchers and family planning program managers widely used that model. It was implemented in two computer programs and produced in English, French and Spanish.

In 1993 The Futures Group produced a revised version of this model called Target-Cost. This version expanded the model's scope in several ways, primarily by adding a cost component to the calculations. A detailed manual was also prepared containing information on costing family planning programs. The computer program was available in English, French, Spanish, Russian and Vietnamese.

In 1989 Research Triangle Institute began the development of FamPlan. FamPlan could also project the numbers of users and acceptors required to meet a fertility or prevalence goal, but was used most often to project the future implications of achieving a certain number of acceptors of different family planning methods. In addition, FamPlan contained a module to calculate the costs and benefits of family planning and to calculate the improvements in per capita coverage of social services that might be expected as a result of reduced population growth.

The new family planning module in Spectrum continues the FamPlan name and incorporates elements of the previous programs. The benefit-cost portion of the old FamPlan model has been moved to a separate module in Spectrum.

The new family planning module (FamPlan, Version 4) incorporates a number of changes suggested by users of earlier versions of both Target and FamPlan as well as changes required to meet the new needs of reproductive health programs following the ICPD guidelines. First, it includes a number of new options for setting program goals (meeting unmet need, achieving desired fertility). Second, it contains some modifications to the equations of the proximate determinants of fertility that have been developed from the wealth of new information from Demographic and Health Surveys since the original framework was developed. Third, the program includes some new options to make it more flexible (such as calculating on an age-aggregate or age-specific basis). Finally, the program has been rewritten in Windows and integrated into the Spectrum system of policy models under the POLICY Project.

It should be noted that the provision of high-quality family planning services is a complicated process requiring skilled and dedicated personnel; appropriate technologies, legislation and infrastructure; and adequate funds. Although FamPlan can be used to calculate the family planning program costs to achieve a particular goal, it does not imply that the goals can be achieved merely by allocating the necessary funds.

In recent years there has been much public discussion about the use of targets in family planning programs. In some programs, national targets are translated into regional, district, facility and even personnel targets. In some cases, individual family planning workers are given annual targets for new acceptors that they must meet. These approaches have been rightly criticized. They put the emphasis on achieving numerical contraception targets rather than on providing high-quality reproductive health services to those who need it. They also encourage misreporting by family planning workers trying to achieve impossible targets. India, for example—in recognition of these problems—announced the abolition of its national targeting system in April 1996. FamPlan is not intended to be used for setting individual targets for family planning workers.
FamPlan's purpose has always been to help planners and policymakers understand the requirements for achieving national goals. Users have always been encouraged to think about the needs of the population when considering future goals. This latest version of FamPlan includes additional options that make this point even more explicit. Goals can be set in terms of meeting unmet need or achieving the desired fertility rate. The use of FamPlan for examining national goals should not be confused with the practice of setting individual-level targets for family planning workers. In countries such as India, where target-driven approaches are being discarded, there is an urgent need for new approaches to setting goals and monitoring achievement. Various approaches based on unmet need and desired fertility have been proposed and are being tested. FamPlan can help in the development and application of these new approaches by illustrating the requirements to achieve various need-based goals.

7.3.2   Why make family planning projections?

Family planning projections may be made for several reasons. One of the most common reasons is to estimate the service and resource requirements to meet a family planning goal. The goal may be expressed in terms of demand (i.e., meeting unmet need, achieving the desired total fertility rate); resources available (how much can be done with a given level of expenditure); continuance or improvement of past trends (in terms of annual increases in prevalence or acceptors); health indicators

(reducing the number or percentage of high-risk births); or in demographic terms (achieving a goal for population growth rate or the total fertility rate, such as replacement-level fertility). Family planning projections can help in setting the goal. By showing the resources required to achieve any proposed goal, these projections can help planners choose goals that are attainable and useful.

Once goals are chosen, it is important to estimate the service and resource requirements to achieve those goals. This is important at the aggregate level and even more important when disaggregated by sector. Thus the plan can be specific about the contribution expected from the commercial sector and from nongovernmental organizations (NGOs), for example. The public sector resources required to achieve the goal can be estimated and planned for several years.

Another important use of family planning projections is the examination of alternative program configurations. Rather than simply project the current configuration into the future, the analyst can ask, "What would happen if new methods were introduced? How much would it help if the commercial sector could be stimulated to contribute more? Would the addition of a small fee for public sector services have a significant impact on the ability of the program to achieve its goals?"

7.3.3 Steps in making a family planning projection

There are six key steps in making most population-based projections within FamPlan. The amount of time spent on each step may vary, depending on the application, but most projection activities will include at least these six steps.

1. **Prepare a demographic projection.** FamPlan requires a population projection prepared with DemProj. This projection should be prepared first or at the same time as the FamPlan projection. The first year and final year of the DemProj projection will determine the span of the FamPlan projection; the DemProj manual contains instructions on the steps associated with this module.

2. **Collect data.** At a minimum, two types of base year data need to be collected: (1) information on the proximate determinants of fertility (see glossary) and (2) program characteristics, including method and source mix. Some additional information (unmet need, costs of services) is required for most projections. Since the projection will only be as good as the data on which it is based, it is worth the effort to collect and prepare appropriate and high-quality data before starting the projection.

3. **Make assumptions.** Family planning projections require assumptions about the future levels of the family planning goals and method characteristics. These assumptions should be carefully considered and based on reasonable selection guidelines.

4. **Enter data.** Once the base year data are collected and decisions made about projection assumptions, the FamPlan module of the Spectrum model can be used to enter the data and make a population projection.

5. **Examine projections.** Once the projection is made, it is important to examine it carefully. This includes consideration of the various family planning indicators produced. Careful examination of these indicators can act as a check to ensure that the base data and assumptions were understood and entered correctly into the computer program. This careful examination is also required to ensure that the consequences of the assumptions are fully understood.

6. **Make alternative projections.** Many applications require alternative projections. Once the base projection has been made, the program can be used to quickly generate alternative projections as the result of varying one or several of the model assumptions.

7.3.4   Before you get started

First, you will need to run DemProj, part of the Spectrum system of policy models; please refer to its manual for more information. Then, you will need to collect data and make certain decisions before running the model. For example, you will need to decide the following at the very beginning:

- The types of contraceptives to include in the model. You may choose any or all of the following:

  o **Condom:** male and female

  o **Sterilization:** male and female

  o **Injectable:** 3 month (Depo Provera), 2 month (Noristera), 1 month (Lunelle), 6 month, Uniject

  o **Implant:** Implanon, Jadelle, Sino-implant

  o **Pill:** Standard Daily Regiment, Progestin only, Peri-coital contraception (PCC)

  o **Traditional:** periodic abstinence, withdrawal, traditional (not specified)

  o **IUD:** Copper-T 380-A IUD, LNG-IUS

  o **Fertility Awareness:** LAM, SDM

  o **Barrier methods:** vaginal barriers, spermicides

  o **Custom methods**

- method sources: you may enter as many or as few as you wish

- age group option: one age group of 15-49, including all women of reproductive age, or seven five-year age groups (15-19, 20-24, etc. until the final category of 45-49).

- Abortion option: specify total abortion rate or calculate from unintended pregnancies.

- whether to disaggregate unmet need by spacing or limiting births.

- whether to calibrate projection to country survey year.

- which of these goals should be considered: reducing unmet need for contraception, total wanted fertility, reaching a goal for contraceptive prevalence, or reaching a goal for total fertility rate.

The data you will need include:

- for the contraceptive methods you have chosen to include, the units of CYP (couple-years of protection) for the temporary methods, the average duration of use for the long-term methods, and the average age at sterilization for the permanent methods.

- the effectiveness rates for the methods you have chosen to include.

- the method mix (e.g., condom usage is   percent of the total contraceptives used).

- the sources of the various methods, by percentages.

- the cost per user of each method included in the model, by source.

- the fees per user of each method, by source.

- the proximate determinants, including the percentage of women ages 15-49 married or in union, the number of months of postpartum insusceptibility, the abortion rate, and sterility.

You will also need to make decisions about the model's goal options: what do you want to change? How quickly?
These inputs are all described in <u>FamPlan input editors</u>.

7.3.5   FamPlan input editors

FamPlan requires:

(1) data describing the use of family planning in the country or region being studied and

(2) data about the use, effectiveness and costs of the different contraceptive methods and services. Some of these data (e.g., prevalence of contraceptive use) must be specific for the area being studied and some of the data (e.g., method effectiveness) can be based either on local data or on international averages when local data are unavailable.

7.3.5.1   Configuration

FamPlan contains a number of different options that can be used to tailor the model to the needs of different situations.

Contraceptive methods

The family planning program must be described in terms of the contraceptive methods that are available. All methods that are available in the program or that might become available during the projection period should be included in the analysis. The methods that may be included in FamPlan projections are:

- **Condom** - male and female

- **Sterilization** - male and female

- **Injectable** - 3 month (Depo Provera), 2 month (Noristera), 1 month (Lunelle), 6 month, Uniject

- **Implant** - Implanon, Jadelle, Sino-implant

- **Pill** - Standard Daily Regiment, Progestin only, Peri-coital contraception (PCC)

- **Traditional** - periodic abstinence, withdrawal, traditional (not specified)

- **IDU** - Copper-T 380-A IUD, LNG-IUS

- **Fertility awareness** - LAM, SDM

- **Barrier methods** - vaginal barriers, spermicides

- **Custom methods**

Method sources

Sources of contraception may also be specified in FamPlan projections. The user has complete flexibility in specifying sources. The list can be simple and generic, such as "public," "private," and "NGO'"or may include specific sources such as "Ministry of Health clinics," "social marketing," "Profamilia," etc. All the important sources of family planning services and commodities should be included. You do not have to

include any sources in the projection; if you do not, FamPlan will treat the projection as if all methods came from one source. However, in most cases, it will be useful to include sources.

Goal option

In order to make a projection of family planning requirements, it is necessary to state the goal of the family planning program. In the FamPlan program, there are four possible goals from which you can select. They are:

Reducing unmet need for contraception

Total wanted fertility

Reaching a goal for contraceptive prevalence

Reaching a goal for total fertility rate

Age group option

There are two age group options available in FamPlan: ages 15-49 clustered into one single age group, or seven five-year age groups (15-19, 20-24, 25-29, 30-34, 35-39, 40-44, 45-49). Either option will work reasonably well. More precise estimates will be produced with five-year age groups. However, the data requirements are considerably larger and the extra precision may not be needed for many projections. Generally, the five-year age group option should be chosen for full-scale applications that are made for planning purposes, and the single age group option may be used when the projections are being used to illustrate trends or to do initial examinations of potential future goals.

Abortion option

The specification of induced abortion is always a problem in FamPlan projections. Abortion is an important proximate determinant in many countries. However, good information about the amount of abortion is often not available. In practice, the number of abortions may have little impact on the projections if the abortion rate does not change significantly over the projection period. In many cases, users are tempted to assume that abortion will not change just because there are no good data on abortion.

In order to make it more likely that users will consider abortion carefully, FamPlan provides two methods of specifying the effects of abortion. In the first, the user specifies the total abortion rate. This is the average number of abortions that a woman would have during her lifetime if she survived to age 50 and had abortions according to the current pattern of age-specific abortion rates. This is the standard approach. When data are available they are often expressed in terms of the total abortion rate. The disadvantage to this approach is that the user may have little feeling for how this rate may change in the future.

In the second approach, the user specifies the proportion of unintended pregnancies that end in abortion. It may be more difficult to find country-specific data to make this assumption, but the advantage to using this number is that it allows the total abortion rate to vary within the model in the future (even if the proportion of unintended pregnancies ending in induced abortion remains constant) due to changes in prevalence and unmet need.

As noted, however, it is very difficult to obtain a good empirical estimate of the proportion of unintended pregnancies which terminate in induced abortions. This type of information needs to come from surveys - but abortions are notably underreported in surveys, especially in those countries where abortion is illegal and/or is socially disapproved. That a pregnancy was unintended is also underreported in retrospective surveys.

This option of FamPlan, then, serves best as a modeling option. It permits comparing the consequences of all vs. some vs. none of the unintended pregnancies being terminated by abortions. A recent figure for the United States showed that nearly half (47 percent) of its unintended pregnancies end in abortion (and 13 percent in miscarriage; Gold, 1990). This figure could be a starting point for illustrative comparisons.

Disaggregate need by spacing and limiting

If you select a goal of achieving a particular level of contraceptive prevalence (see discussion below of the goals of reducing unmet need or contraceptive prevalence), the goal can be specified either in terms of total prevalence or in terms of spacing and limiting prevalence, separately. Since the need for family planning for spacing and limiting may evolve quite differently over time, it is generally recommended that you select the "Yes" option. This selection is particularly important for method mix.

Projection calibration

The projection calibration lists the survey year for the country.

7.3.5.2 Family planning

7.3.5.2.1 Method mix

Using the editor

Method mix is the percentage of all users who use a particular method. These figures should sum to 100 percent. The best source of method mix for the base year is likely to be a national survey such as DHS, WFS or CPS.

1. Scroll to the right or left to see all the years.

2. Enter the method mix for the projection. The method mix is the percentage of all users of each method. Thus, the values for all of the methods should sum to 100. If the values for at least one year do not sum to 100, you will see an error message when you click the "Ok" button to leave the editor. This is a warning that you should return to the Method Mix editor and correct the inputs until all columns sum to 100. (It is just a warning. The program will not force you to make all the columns sum to 100. You can consider dual method use by allowing the method mix to sum to more than 100. If a column sums to 110, it indicates that 10 percent of users are using more than one method at a time. In this case, the prevalence and TFR calculations will be correct, while the commodity requirements will reflect the fact of dual method use by some portion of users.)

3. The Method Mix editor and the Source Mix editor both have an additional button labeled "Normalize." Clicking this button will force the entries to sum to 100 for each year by adjusting each entry up or down by the same proportion.

4. For some goals, you can specify the method mix separately for spacers and limiters. Select spacers or limiters by clicking on the appropriate button near the bottom of the editor (not shown).

What is method mix?

Method mix is the percentage of all users who use a particular method. These figures should sum to 100 percent. The best source of method mix for the base year is likely to be a national survey such as DHS, WFS or CPS.

Estimating future method mix patterns

Survey data can provide information useful to estimating future method mix patterns. Those who intend to use family planning in the future are often asked which methods they prefer to use. This preferred method mix may indicate which methods may be in demand in future years. Another approach is to examine the current mix of contraceptive users who are deemed "knowledgeable" about contraception. A "knowledgeable" user is often defined as a user who knows at least four modern methods. An alternative definition is users who mention spontaneous awareness of two supply methods and one clinical method and who also know where they can obtain each of these methods. The current method mix of these knowledgeable users may indicate likely future changes in method use if knowledge and access improve. A third approach is to examine the method mix currently being used by urban, educated women. These women are assumed to have good knowledge of methods and access to services. The method mix of this group may indicate likely future directions if the family planning program is able to increase knowledge and access.

A more detailed approach to future method mix involves the definition of an appropriate method mix. An appropriate mix is the distribution of methods when every woman who needs to use contraception uses a method suited to her fertility goal and personal characteristics. For example, women who wish to delay the next birth are candidates for a temporary method of contraception, such as orals or the injectable. For those who do not want more children, sterilization or another long-term method is ideal. There are some women who have unrecognized physical health conditions or personal characteristics that place them at an elevated risk for problems related to pregnancy and childbearing. Included in this category are women who are too young or too old to have a child, women who recently had a birth and should ideally wait at least two years before having another child, and those who already have many children and, for health reasons, should not have more. Methods suited to the particular circumstances of current and potential users can define an appropriate method mix. The FamPlan model can be used to examine the resources required to allocate this appropriate method mix to the population.

More information

More information on these approaches to defining the future method mix can be found in several publications (see Galway, Katrina and Stover (1995)).

If the TFR is changing appreciably during the projection period, it is likely that method mix will also change. In addition, there may be specific program goals set by the family planning program regarding method mix. Whatever the case, careful thought should be given to how method mix will change in the future since a particular mix has different effects on a number of factors, including average effectiveness, prevalence, costs, and the logistics burden.

Figures 2 and 3 show the method mix of users in Muslim and non-Muslim countries, based on information in a set of 273 national surveys from 101 countries. The method mix changes as prevalence rises, moving toward less traditional method use and greater dominance of longer acting methods. In Muslim countries the IUD has been considerably more prominent where prevalence is high. In non-Muslim countries increasing prevalence is associated with greater roles for injections (particularly in sub-Saharan Africa) and female sterilization.

Figure 2: Method Mix – Muslim Countries
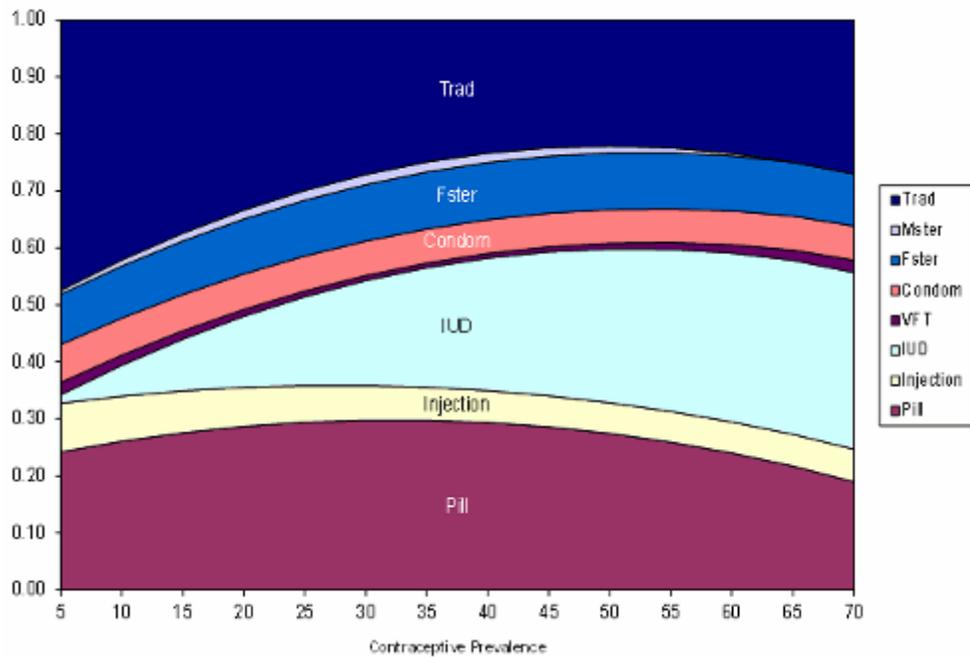
Figure 3: Estimated Evolution of Method Mix for SSA
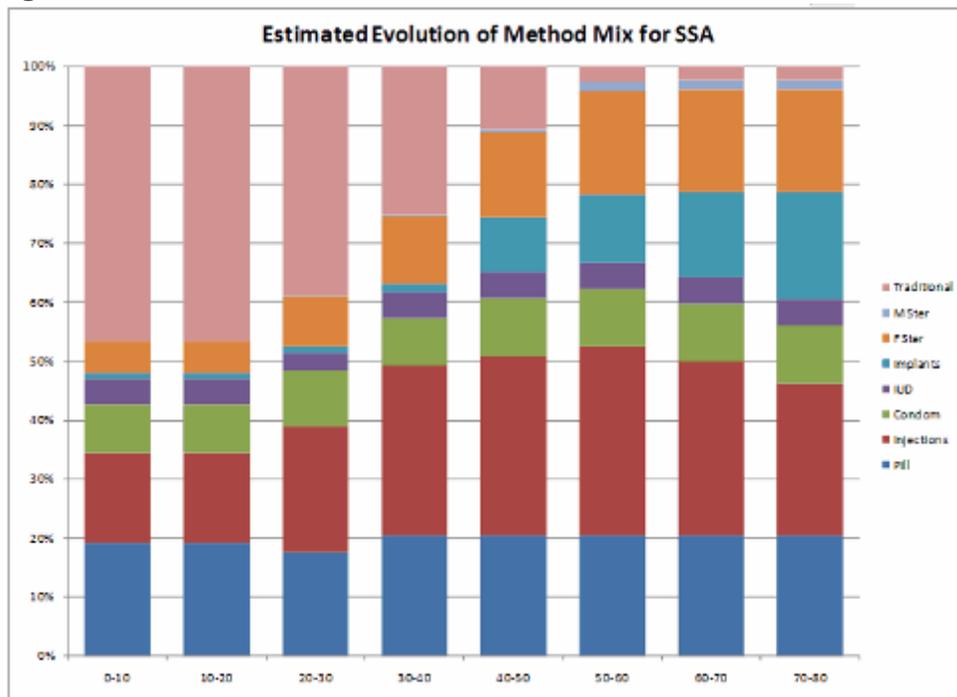
7.3.5.2.2 Source mix

Using the editor

1. Scroll to the right or left to see all the years.

2. Enter the source mix for the contraceptive methods in the projection. In the screen shown, the first contraceptive method is condom. The source mix is the percentage of all users or acceptors who get their services from each source. Note that it is not necessary to enter values for all sources for all methods. Some sources may be zero for some methods. However, the source mix should sum to 100 for each method and each year.

To enter source data for the other contraceptive methods in the projection, select a tab near the bottom of the screen. In the example screen shown, contraceptive methods include Male condom, Female sterilization, Vaginal barrier, Withdrawal, Periodic abstinence and Traditional (not specified).

More information

FamPlan can project requirements by source if information on sources is available. If information is unavailable or output on requirements by source is not desired, the inputs for source mix can be ignored. If source specific information is required, the source mix in the base year and future years must be entered. The source mix is the percentage of all users of a particular method who obtain services from each source. The best information on source of services and supplies is usually a national survey. The mix of sources is affected by several factors, including regulation, the extent of government involvement in family planning services, and the strength of the private sector. For a good discussion of changes in source mix over time, see Cross et al. (1991). For a discussion of factors affecting source mix, see Winfrey, Heaton, and Dayaratna (1997).

Survey questions concerning source of supply have improved over time to enable a more accurate determination, particularly for the DHS round of surveys. However, determining the base year source mix is not always a straightforward exercise. Even though the categorization of source types has improved, some respondents may not correctly identify the true nature of their source. For example, some respondents may only know that they go to a "clinic" for their services and supplies and not whether the clinic is operated by the public, private or NGO sector.

Another area of confusion arises in situations where a specific source of supply receives support from a variety of entities. For example, a source may receive public funding to operate and be located within a public sector structure but have services and supplies actually provided by private doctors. Classification of such a source as a public or a private one becomes difficult.

Table 8 shows the mix of public, private and NGO sources for a number of countries that have had a recent DHS.

	Modern Methods Only: Percent Using		Source of Current Method for Married/in Union Women					
	All Women	Married/ in Union	Public	Private Medical	Other Private	Other	DK/ Missing	Total
Sub-Saharan Africa								
Benin 2006	6.9	6.1	42.1	34.7	19.1	4.1		100
Burkina Faso 2010	14.3	15.0	73.7	11.4	12.6	0.3		98
Burundi 2010	11.0	17.7	87.2	10.0	1.6	0.3	0.9	100
Cameroon 2011	16.1	14.4	20.0	26.9	49.9	1.5	1.6	100
Ethiopia 2011	18.7	27.3	82.0	13.4	1.3	0.1	3.2	100
Ghana 2008	13.5	16.6	39.4	51.1	3.0	1.0	5.5	100
Kenya 2008/9	28.0	39.4	57.3	35.9	5.8	0.5	0.5	100
Lesotho 2009	34.9	45.6	62.7	21.4	12.7	3.1	0.1	
Liberia 2007	11.7	10.3	50.8	30.5	9.6	2.8	6.3	100
Madagascar 2008/09	23.0	29.2	72.8	19.7	6.8	0.3	0.5	100
Malawi 2010	32.6	42.2	73.8	8.9	3.5	13.4	0.4	100
Nigeria 2008	10.5	9.7	23.3	60.4	13.1	2.0	1.2	100
Rwanda 2010	25.2	45.1	91.6	4.3	2.6	0.8	0.7	100
Sierra Leone 2008	8.2	6.7	50.4	38.9	6.4	1.4	2.9	100
Uganda 2011	20.7	26.0	46.6	45.4	7.0	0.6	0.4	100
Zambia 2007	24.6	32.7	68.0	16.5	12.5	1.8	1.2	100
Zimbabwe 2010/11	40.5	57.3	73.4	14.1	10.4	1.4	0.6	100
NorthAfrica/WestAsia/Europe								
Albania 2008/09	7.9	10.6	52.7	40.2	6.3	0.8		100
Armenia 2010	16.9	27.2	37.3	60.7	1.9	-		100
Jordan 2009	40.4	42.0	46.0	54.0	-	-		100
Central Asia								
Kazakhstan 1999	41.5	56.8	89.5	6.9	-	3.7		100
Kyrgyz Republic 1997	35.3	48.9	96.9	0.6	1.1	1.3		100
Turkmenistan 2000	33.8	53.1	98.5	1.0	-	0.5		100
Uzbekistan 1996	36.6	51.3	98.3	0.3	0.2	1.1		100
South & Southeast Asia								
Bangladesh 2007	na	47.5	50.2	37.8	6.4	5.3	0.4	100
Cambodia 2010	21.7	34.9	51.6	30.3	13.3	3.2	1.5	100
Indonesia 2007	na	57.4	22.2	69.1	7.6	1.0	0.1	100
Maldives 2009	na	27.0	63.1	31.0	1.0	2.8	2.1	
Nepal 2001	33.2	43.2	69.0	19.8	0.8	8.9	1.5	100
Philippines 2008	21.8	34.0	46.3	51.2	2.4	0.1	0.1	100
Latin America &Caribbean								
Colombia 2010	56.9	72.9	56.1	40.6	0.8	2.1	0.5	100
El Salvador 2008	45.5	66.1	75.0	13.8	10.3	0.5	0.4	100
Guatemala 2008/09	29.9	44.0	60.2	38.0	-	1.1	0.7	100
Guyanaa 2009	32.5	40.0	48.6	33.1	16.0	1.0	1.4	100
Jamaica 2008/09	52.0	68.2	48.2	39.0	-	10.0	1.2	98.4
Paragyay 2008	52.4	70.7	34.7	57.0	1.4	5.6	1.4	100
Peru 2011	35.3	51.1	64.3	33.8	1.1	0.8		100

na: not available

Source: Macro International Inc, 2013. MEASURE DHS STATcompiler. http://www.measuredhs.com, January 18 2013.

7.3.5.2.3 Proximate determinants

Using the editor
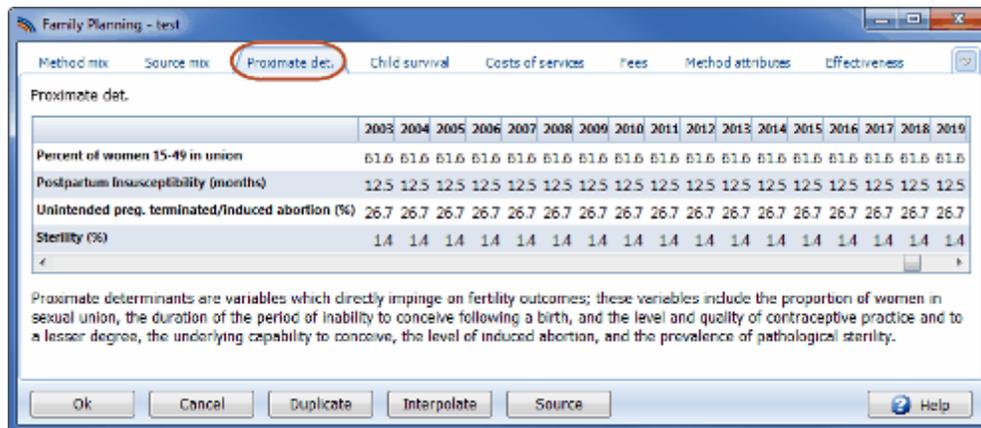
1. Scroll to the right or left to see all the years.

2. Enter values for these proximate determinants of fertility for each year of the projection. In many cases it will be sufficient to enter a base year value and a value for the final year of the projection, and then to interpolate between these two years.

Proximate determinants of fertility

For many years, the factors which directly affected fertility levels were called "intermediate fertility variables," being intermediate between major social forces, like urbanization and education, and childbearing. They included all factors which determine whether a conception transpires and whether that conception ends in a live birth. As better measures and a greater understanding of this set of factors evolved, the variables were reduced in number and labeled as "proximate determinants of fertility" or variables which directly impinge on fertility outcomes.

With the increased ability to measure these several variables, the most important variables in terms of influencing resulting fertility were found to be: the proportion of women in sexual union, the duration of the period of inability to conceive following a birth, and the level and quality of contraceptive practice and to a lesser degree, the underlying capability to conceive, the level of induced abortion, and the prevalence of pathological sterility.

Percentage in Union

In order to determine the number of women of reproductive age who are in union, FamPlan requires an estimate of the percentage of women 15-49 who are in union. The best source for this figure will usually be a national census or national survey.

The information presented in **Table 20** consists of recent estimates available on the percentage of women of reproductive age (WRA) in union for a number of countries. For many of these countries, the information comes from the most recent DHS or CPS survey.

Table 20: Percentage of Women of Reproductive Age Who Are in Union

Region and Country	Percent in Union	Region and Country	Percent in Union
Sub-Saharan Africa		**Central Asia**	
Benin 2006	75.3	Turkmenistan 2000	61.7
Burkina Faso 2003	77.4	Uzbekistan 2002	68.1
Burundi 2010	57.7	**Average**	**64.9**
Cameroon 2004	67.2		
Chad 2004	76.6		
Eritrea 2002	65.5	**South & Southeast Asia**	
Ethiopia 2011	62.3	Cambodia 2010	62.0
Gabon 2000	54.1	India 2005/06	74.8
Ghana 2008	58.5	Indonesia 2002/03	70.9
Guinea 2005	79.1	Nepal 2011	75.8
Kenya 2008/09	58.3	Pakistan 2006/7	71.1
Liberia 2007	64.0	Philippines 2008	61.9
Madagascar 2008/09	69.3	Vietnam 2009/10	60.2
Malawi 2010	67.4	**Average**	**68.1**
Mali 2006	84.8		
Mauritania 2000/01	58.8	**Latin America & Caribbean**	
Mozambique 2003	70.3	Bolivia 2008	60.0
Namibia 2006/07	35.2	Colombia 2010	52.7
Niger 2006	86.1	Dominican Republic 2007	56.7
Nigeria 2008	70.6		
Rwanda 2010	50.4	Haiti 2005/06	58.8
Senegal 2010/11	66.0	Nicaragua 2001	56.8
Tanzania 2010	63.3	Peru 2007/08	56.2
Uganda 2006	62.6	**Average**	**57.2**
Zambia 2007	61.6		
Zimbabwe 2010/11	61.1		
Average	**65.5**		
North Africa/West Asia/Europe			
Armenia 2000	64.1		
Egypt 2000	62.8		
Jordan 2002	51.7		
Average	**59.5**		

Sources: Demographic and Health Surveys and other national surveys.

The percentage of women in union usually changes as a country develops. Typically, the average age at first marriage rises with development. The result of this change is that the percentage of women in union declines. **Figure 5** shows that the percentage of women in union is generally lower at higher levels of per capita gross national income (GNI). For most countries, the percent in union is likely to decline as the country develops, education enrollment increases, and the percentage of the population living in urban areas increases, primarily due to the increase in the age at first marriage. Model users should consider this pattern when estimating future values of the percentage of WRA in union.

Figure 5: Percentage of Women Aged 15-49 in Union versus GNI Per Capita
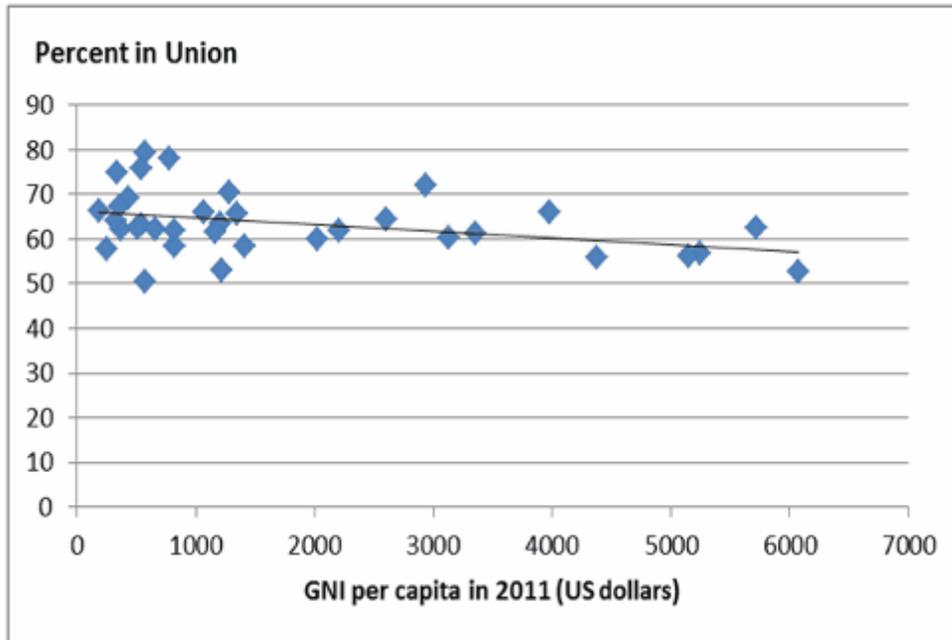
Sources: ICF International, 2012. MEASURE DHS+ STATcompiler. http://www.measuredhs.com, January 18, 2013; The World Bank. http://data.worldbank.org/indicator/NY.GNP.PCAP.CD, January 18, 2013.

Duration of Postpartum Insusceptibility

Postpartum insusceptibility is the period after a birth during which a woman is not exposed to the risk of pregnancy either because of postpartum amenorrhea or because of postpartum abstinence. FamPlan requires an estimate of the average duration of postpartum insusceptibility, expressed in months. Estimates may be available from national surveys; data for a number of countries that have had DHS surveys are provided in **Table 21**.

Table 21: Mean Duration of Postpartum Insusceptibility (PPI), in Months

Country	PPI	Country	PPI
Sub-Saharan Africa		**North Africa/West Asia/Europe**	
Benin 2006	15.7	Armenia 2010	5.5
Botswana 1988	14.6	Egypt 2008	7.2
Burkina Faso 2003	20.4	Jordan 2009	5.7
Burundi 2010	15.3	Morocco 1992	8.3
Cameroon 2004	14.4	Tunisia 1988	8.1
CAR 1994/95	17.5	Turkey 1998	6.7
Chad 2004	16.7	Yemen 1997	9.4
Comoros 1996	11.3	**Average**	**7.3**
Cote d'Ivoire 1998/99	17.7		
Eritrea 2002	17.0	**Central Asia**	
Ethiopia 2011	17.1	Kazakhstan 1999	9.4
Gabon 2000	13.0	Kyrgyz Republic 1997	10.1
Ghana 2008	15.2	Turkmenistan 2000	8.8
Guinea 2005	22.4	Uzbekistan 1996	8.7
Kenya 2008/09	12.7	**Average**	**9.3**
Liberia 2007	15.5		
Madagascar 2008	12.5	**South & Southeast Asia**	
Malawi 2010	14.9	Bangladesh 2007	9.6
Mali 2006	13.6	Cambodia 2010	10.6
Mauritania 2000/01	12.9	India 2005/06	10.1
Mozambique 2003	19.1	Indonesia 2007	10.3
Namibia 2006/07	15.3	Myanmar 1997	11.0
Niger 2006	16.4	Nepal 2011	12.5
Nigeria 2008	14.9	Pakistan 2006/7	8.4
Rwanda 2010	14.4	Philippines 2008	8.7
Senegal 2010	15.1	Sri Lanka 1987	10.2
South Africa 1998	16.0	Thailand 1987	9.3
Sudan 1990	14.7	Vietnam 2002	10.3
Tanzania 2010	13.3	**Average**	**10.1**
Togo 1998	19.3		
Uganda 2000/01	14.1	**Latin America & Caribbean**	
Zambia 2001/02	16.3	Bolivia 2008	12.5
Zimbabwe 1999	15.1	Brazil 1996	8.1
Average	**15.6**	Colombia 2010	9.8
		Dominican Republic 2007	6.5
		Ecuador 2004	9.8
		El Salvador 2002/03	10.4
		Guatemala 2002	12.6
		Haiti 2005/06	12.3
		Mexico 1987	7.8
		Nicaragua 2001	11.2
		Paraguay 1990	8.3
		Peru 2007/08	13.3
		Trinidad & Tobago 1987	5.8
		Average	**9.9**

Source: Demographic and Health Survey reports.

Postpartum infecundability has a tendency to decline as a country develops, due to reductions in the prevalence and duration of breastfeeding and the decline of the practice of postpartum abstinence. The increase in female employment in the formal labor force and the increase in urbanization that usually occur over time can make it more difficult for women to breastfeed for long periods. However, a number of countries have implemented programs to encourage more breastfeeding. An examination of trends in

40 developing countries (not shown) that compares PPI in the earliest survey to the latest one shows a net decline in 20 countries, a net rise in 10, and essentially no change in 10.

Figure 6 shows the average PPI duration for selected countries. The three countries in West Asia/North Africa (Egypt, Jordan, and Turkey) lie at the bottom, at about 3-6 months, whereas the five in Sub-Saharan Africa (Ghana, Kenya, Mali, Senegal, and Uganda) lie at the top, at about 11-17 months. The three in Asia (Bangladesh, India, and Indonesia) lie between 4-11 months. The four in Latin America (Bolivia, Colombia, Dominican Republic, and Peru) vary, with two high and two low.

Figure 6: Change in the Mean Duration of Postpartum Insusceptibility (PPI) for Selected Countries (in months)
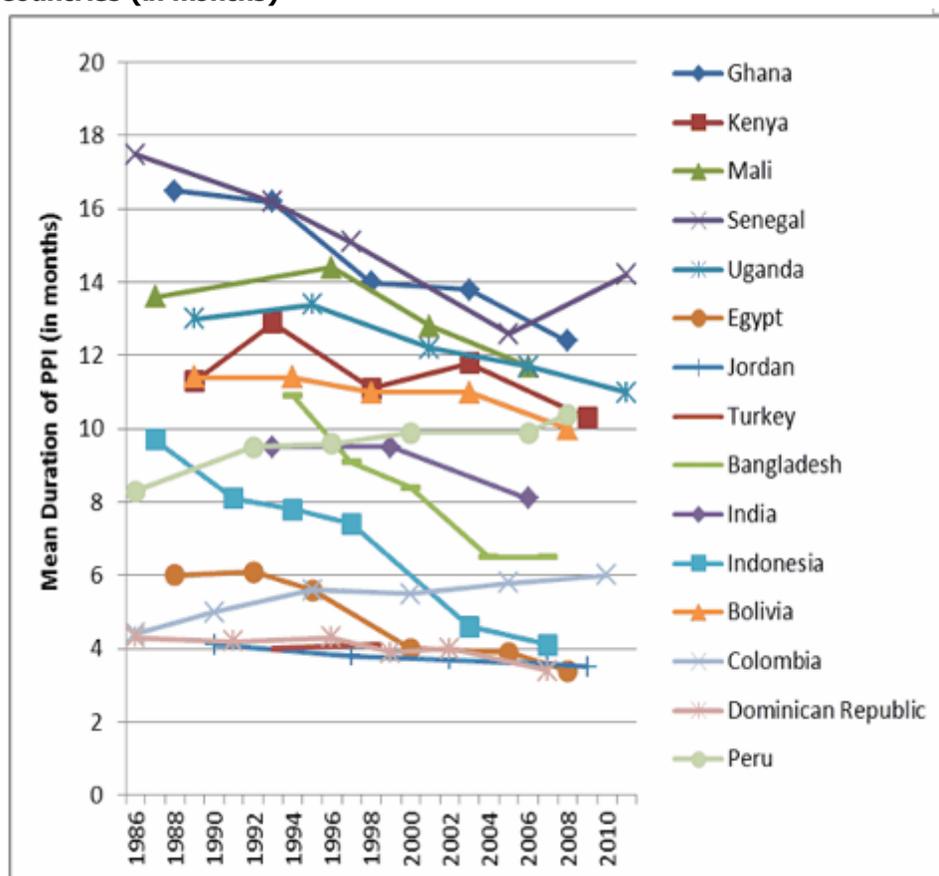
Total Abortion Rate

The total abortion rate is the average number of induced abortions a woman would have if she survived to age 49 and had abortions at the prevailing age-specific rates. Thus, in concept, it is similar to the total fertility rate. Since abortions are illegal in many countries, data on abortion are not widely available. Information that is available for developing countries is usually derived from incomplete statistics, surveys, or indirect estimates based on hospital data. **Table 22** presents data primarily compiled by The Alan Guttmacher Institute (in 1997) on total abortion rates for a number of countries, and in addition contains several special estimates based on recent survey data.

Table 22: Total Abortion Rates in Selected Countries

Country	Total abortion rate	Notes	Country	Total abortion rate	Notes
Albania, 1996	0.82	2	Korea (South), 1996	0.59	2
Armenia, 1996	1.06	2	Kyrgyzstan, 1996	0.67	2
Australia, 1995-1996	0.57	1	Latvia, 1996	1.33	1
Azerbaijan, 1996	0.49	2	Lithuania, 1996	1.03	2
Bangladesh, 1995-1996	0.11	2	Macedonia, 1996	0.86	2
Belarus, 1996	2.04	1	Mexico, 1990	0.82	2
Belgium, 1996	0.21	1	Moldova, 1996	0.83	2
Brazil, 1991	1.33	2	Mongolia, 1996	0.78	2
Bulgaria, 1996	1.55	1	Netherlands, 1996	0.20	1
Canada, 1995	0.49	1	New Zealand, 1995	0.49	1
Chile, 1990	1.59	2	Norway, 1996	0.47	1
China, 1995	0.78	2	Peru, 1989	1.81	2
Colombia, 1989	1.18	2	Puerto Rico, 1991-1992	0.68	1
Croatia, 1996	0.38	2	Romania, 1996	2.34	2
Cuba, 1996	2.33	1	Russian Federation, 1995	2.56	2
Czech Republic, 1996	0.63	1	Scotland, 1996	0.34	1
Denmark, 1995	0.48	1	Singapore, 1996	0.48	1
Dominican Rep., 1992	1.53	2	Slovak Republic, 1996	0.59	1
England & Wales, 1996	0.48	1	Slovenia, 1996	0.70	1
Estonia, 1996	1.63	1	South Africa, 1997	0.08	2
Finland, 1996	0.31	1	Spain, 1996	0.17	2
France, 1995	0.37	2	Sweden, 1996	0.56	1
Georgia, 1996	0.66	2	Switzerland, 1996	0.25	1
Germany, 1996	0.23	1	Tajikistan, 1993	1.0-1.4	Turner
Hong Kong, 1996	0.45	2	Tunisia, 1996	0.26	1
Hungary, 1996	1.07	1	Turkey, 1993	0.75	2
Iceland, 1994	0.38	1	Turkmenistan, 1993	1.0-1.2	Turner
India, 1995-1996	0.08	2	Ukraine, 1996	1.72	2
Ireland, 1996	0.18	2	United States, 1996	0.69	1
Israel, 1995	0.43	1	Uzbekistan, 2002	0.95	MOH,U
Italy, 1996	0.34	2	Vietnam, 1996	2.50	2
Japan, 1995	0.40	2	Yugoslavia, 1993	1.64	2
Kazakhstan, 1996	1.32	1	Zambia, 1983	0.01	2

Notes:
1. Believed to be complete
2. Incomplete or of unknown completeness

Sources:
All but three entries come from Stanley K. Henshaw, Susheela Singh, and Taylor Haas, "The Incidence of Abortion Worldwide," *International Family Planning Perspectives*, 1999, 25 (Supplement):S30S38.

MOH,U – *Uzbekistan Health Examination Survey 2002*. Issued by Ministry of Heath, State Department of Statistics and ORC Macro. April 2004.

Turner, R. "Tajiks Have the Highest Fertility Rates in Newly Independent Central Asia." *Family Planning Perspectives* 25 (3): 141-142.

If information is unavailable, the total abortion rate may be set to zero. On the other hand, if a significant amount of abortions does take place, it is advisable to make some
estimate of the rate in order to be able to use the model to examine the effects of reducing the abortion rate.

It should also be noted that the induced abortion rate is the only one of the proximate determinants that can affect the required level of prevalence, even if it remains constant. This is because the calculation of the abortion index includes the TFR and the prevalence rate. Therefore, if the abortion rate is not set to zero, careful consideration should be given to both the present and future rates. With a TFR of 7, an abortion rate of 1 means that one-eighth of pregnancies are ended by abortions, but at a TFR of 2, an abortion rate of 1 means that one-third of all pregnancies are terminated by abortions.

Sterility

The sterility variable measures both natural sterility and pathological sterility. Since natural sterility is not likely to change much, the major effect will be from pathological sterility. In practice, this variable is likely to be significant only in societies with high levels of pathological sterility resulting in significant infertility and subfecundity. This effect is most pronounced in certain regions of sub-Saharan Africa, where primary and secondary infertility are caused by sexually transmitted diseases. The extent of sterility is gauged by the percentage of women who are childless at the end of the reproductive period. The best sources will be national surveys and censuses that report the percentage of women childless at ages 45-49. **Table 23** presents data on percentages of childless women from a number of DHS reports. These data presume a strong prevailing norm that all married women attempt to have at least one child.

Table 23: Percentage of Women Who Remain Childless at Ages 45-49

Country	All Women	Currently Married Women	Country	All Women	Currently Married Women
Sub-Saharan Africa			**North Africa/West Asia/Europe**		
Benin 2006	1.1	0.8	Armenia 2010	6.1	0.8
Botswana 1988	3.2	3.1	Egypt 2008	5.8	3.5
Burkina Faso 2010	0.9	1.0	Jordan 2009	14.1	6.2
Burundi 2010	3.3	1.7	Morocco 2003/04	9.7	4.1
Cameroon 2011	2.9	2.4	Tunisia 1988	10.5	2.2
CAR 1994/95	8.4	8.7	Turkey 1998	3.7	2.2
Chad 2004	3.4	3.4	Yemen 1997	2.3	1.4
Comoros 1996	2.4	1.8	**Average**	**7.5**	**2.9**
Cote d'Ivoire 1998/99	2.2	0.5			
Eritrea 2002	3.4	2.1	**Central Asia**		
Ethiopia 2011	1.9	1.5	Kazakhstan 1999	5.7	1.6
Gabon 2000	7.0	7.4	Kyrgyz Republic 1997	2.7	1.3
Ghana 2008	1.5	1.3	Turkmenistan 2000	1.4	0.7
Guinea 2005	2.3	2.3	Uzbekistan 2002	3.9	3.3
Kenya 2008/09	0.7	0.0	**Average**	**3.4**	**1.7**
Liberia 2009	0.5	-			
Madagascar 2008/09	5.5	4.7	**South & Southeast Asia**		
Malawi 2004	2.1	1.6	Bangladesh 2007	3.4	2.0
Mali 2006	2.6	2.2	Cambodia 2010	8.3	1.4
Mauritania 2000/01	7.0	4.0	India 2005/06	3.3	2.0
Mozambique 2003	3.1	2.3	Indonesia 2007	4.9	3.0
Namibia 2006/07	3.6	2.0	Maldives 2009	3.5	1.3
Niger 2006	1.7	1.5	Nepal 2011	4.2	2.5
Nigeria 2003	3.3	2.5	Pakistan 2006/07	4.4	2.7
Rwanda 2010	2.0	1.5	Philippines 2008	7.8	3.7
Senegal 2008/09	4.9	-	Sri Lanka 1987	6.8	2.6
South Africa 1998	5.2	4.1	Thailand 1987	6.0	1.2
Sudan 1990	4.4	2.0	Vietnam 2002	6.7	1.7
Tanzania 2010	3.1	1.2	**Average**	**5.4**	**2.2**
Togo 1998	2.1	1.1			
Uganda 2006	3.2	2.6	**Latin America & Caribbean**		
Zambia 2007	1.9	1.4	Bolivia 2008	4.1	2.1
Zimbabwe 2010/11	2.2	1.8	Brazil 1996	8.8	3.9
Average	**3.1**	**2.0**	Colombia 2010	7.5	2.7
			Dominican Rep. 2007	4.7	3.4
			Ecuador 2004	4.5	1.3
			El Salvador 2002/03	2.5	0.8
			Guatemala 2002	4.4	1.8
			Haiti 2005/06	4.3	2.4
			Honduras 2005/06	3.0	1.2
			Nicaragua 2001	4.0	1.0
			Paraguay 1990	4.9	2.7
			Peru 2007/08	5.4	1.4
			Trinidad & Tobago 1987	3.9	2.1
			Average	**4.8**	**2.1**

Source: Demographic and Health Surveys.

Note: Data for additional countries, including European and Western countries, appear in United Nations, World Fertility Report: 2009, published in 2011. Figures for early and recent dates are given to provide time trends, and data are classified separately for women aged 35-39, 40-44, and 45-49.

7.3.5.2.4 Child survival

7.3.5.2.4.1 What is the child survival component of FamPlan?

FamPlan includes a component for child survival which can be used to estimate the effects of contraceptive use upon infant and child mortality, through the intermediate influence of high-risk births. Higher contraceptive use means fewer high-risk births, and fewer high-risk births mean lower infant and child mortality rates.

A user of FamPlan always produces a projection for contraceptive prevalence, and that projection drives the estimated percentage of births that fall into high-risk categories: births below maternal age 18 or above age 34, births occurring within 24 months of a previous birth, and births of orders 4 or higher. All such births are included in one category termed "any risk" births.

In turn, the percentage of "any risk" births drives the infant and child mortality rates. The FamPlan user sets the baseline levels for high-risk births, infant mortality, and child mortality, and the subsequent values for future years are generated automatically.

The IMR (infant mortality rate) is the number of deaths in the first year of life among a starting group of 1000 births.

The U5MR (under five mortality rate) is the number of deaths before age five among a starting group of 1000 births.

In practice each cohort cannot be followed for five years to see what happens, so all births in one calendar years are compared to the number of deaths to children below age five in that same year. The same is done to obtain the number of deaths below age one, for the IMR.

7.3.5.2.4.2 Why make projections for child survival?

Past experience in developing countries shows that as contraceptive use increases, the percentages of births at the later ages and higher orders declines; in addition the percentage of births at short intervals may also decline, as well as births among very young women. Because those births carry elevated mortality rates, an increase in contraceptive use can yield savings in infant/child deaths. By exploring alternative projections for contraceptive use and the consequent changes in expected percentages of high risk births and infant/child deaths, the user can estimate the effects of increased use upon the mortality projections. Additional declines should result from national health programs that directly reduce infant/child mortality, and these in combination with rising contraceptive use and fewer high-risk births can produce substantial savings in deaths. This component only estimates the changes that would arise from increased contraceptive use.

Concepts: The IMR (infant mortality rate) is the number of deaths in the first year of life among a starting group of 1000 births. The U5MR (under five mortality rate) is the number of deaths before age five among a starting group of 1000 births. In practice each cohort cannot be followed for five years to see what happens, so all births in one calendar years are compared to the number of deaths to children below age five in that same year. The same is done to obtain the number of deaths below age one, for the IMR. Illustrative rates appear in Table 34.

7.3.5.2.4.3 Child survival editor inputs

Using the editor
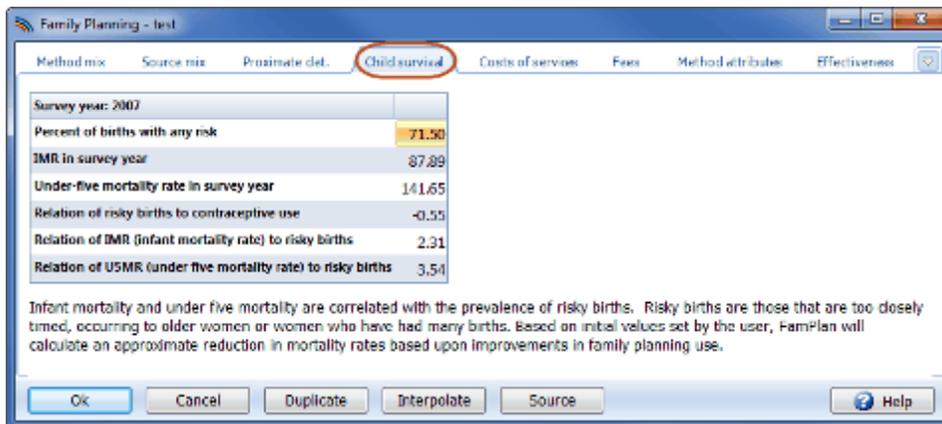
The six baseline inputs, for the first year of the projection as listed above are:

- the percentage of all births classified as "any risk."

- the IMR in the survey year

- the U5MR in the survey year

- Relation of risky births to contraceptive use

- Relation of IMR to risky births

- Relation of U5MR to risky births

NOTE: As explained below the child survival component of FamPlan uses international averages for the three relationships involved: for "Risk" to contraceptive use, for the IMR to Risk, and for the U5MR to Risk. If you wish to override the default values for these and use others that apply to your own country, enter those values as well.

- The slope for the relationship of the percent of births with "any risk" (Y-axis) to the percent of married women using contraception (X-axis).

- The slope for the relationship of the IMR (Y-axis) to the percent of births with any risk (X-axis).

- The slope for the relationship of the U5MR (Y-axis) to the percent of births with any risk (X-axis).

Table 34: Infant and Child Mortality Rates, Percent of Births with Any Risk, and Contraceptive Prevalence. 141 DHS Surveys

	Infant mortality rate (a)	Under-5 mortality rate (a)	Percentage of births with "any risk"	Contraceptive prevalence (b)
Sub-Saharan Africa				
Benin 2006	67.0	125.0	55.6	17.0
Benin 2001	89.1	160.0	57.4	18.6
Botswana 1988	38.4	52.6	52.6	33.0
Burkina Faso 2010	65.0	129.0	58.1	16.2
Burkina Faso 2003	81.4	183.7	59.7	13.8
Burundi 2010	59.0	96.0	56.5	21.9
Burundi 1987	74.0	153.0	60.6	8.7
Cameroon 2011	62.0	122.0	59.7	23.4
Cameroon 2004	74.0	144.0	60.4	26.0
Cameroon 1998	77.0	150.7	64.3	19.3
CAR 1994/95	96.7	157.5	64.4	14.8
Chad 2004	102.0	191.0	69.4	2.8
Chad 1996/97	103.0	194.0	67.8	4.1
Comoros 1996	77.3	104.0	68.0	21.0
Congo (Brazzaville) 2005	75.0	117.0	49.1	44.3
Congo Democratic Rep. 2007	112.2	180.7	60.4	15.0
Eritrea 2002	48.0	93.0	60.8	8.0
Eritrea 1995	66.0	136.	64.6	8.0
Ethiopia 2011	59.0	88.0	62.4	28.6
Ethiopia 2005	77.0	123.0	66.3	14.7
Ethiopia 2000	97.0	166.0	63.4	8.1
Gabon 2000	57.3	88.6	60.4	32.7
Ghana 2008	50.0	80.0	49.7	23.5
Ghana 2003	64.0	111.0	52.9	25.2
Ghana 1998	57.7	108.0	51.6	22.0
Ghana 1993	66.0	119.0	54.3	20.3
Guinea 2005	91.1	163.0	64.9	9.1
Kenya 2008/09	52.0	74.0	54.8	45.5
Kenya 2003	77.0	115.0	56.2	39.3
Kenya 1998	74.4	111.0	55.7	39.0
Kenya 1993	62.0	96.0	63.5	32.7
Liberia 2009	73.0	114.0	-	-
Madagascar 2008/09	48.0	72.0	62.1	39.9
Madagascar 2003/04	58.0	94.0	60.9	27.1
Madagascar 1997	96.0	159.0	66.9	19.4
Malawi 2010	66.0	112.0	55.3	46.1
Malawi 2004	76.0	133.0	53.2	32.5
Mali 2006	96.0	191.0	68.3	8.2
Mali 2001	113.0	229.0	70.2	8.1
Mali 1995/96	122.0	238.0	72.0	6.7
Mauritania 2000/01	69.9	104.2	62.9	8.0
Mozambique 2003	101.0	152.0	60.0	25.5
Mozambique 1997	135.0	201.0	59.1	5.6
Namibia 2006/07	46.0	69.0	41.4	55.1
Namibia 2000	38.0	62.0	47.4	43.7
Niger 2006	81.0	198.0	71.9	11.2
Niger 1998	123.0	274.0	74.0	8.2
Nigeria 2008	75.0	157.0	63.5	14.6
Nigeria 2003	100.0	201.0	65.1	12.6
Nigeria 1999	75.0	140.0	63.7	15.3
Rwanda 2010	50.0	76.0	51.7	51.6
Rwanda 2007/08	62.0	103.0	55.3	36.4

Senegal 2010	47.0	72.0	58.1	13.1
Senegal 2008/09	54.0	85.0	58.8	-
Senegal 2005	61.0	121.0	59.5	11.8
South Africa 1998	45.4	59.4	41.8	56.3
Sudan 1990	70.0	123.7	67.8	8.7
Tanzania 2010	51.0	81.0	55.9	34.4
Tanzania 2004/05	68.0	112.0	54.8	26.4
Tanzania 1999	99.0	147.0	56.6	25.4
Togo 1988	77.3	154.6	61.6	33.9
Togo 1998	79.7	146.3	58.3	23.5
Uganda 2011	54.0	90.0	65.5	30.0
Uganda 2006	71.0	128.0	67.7	23.7
Uganda 2000/01	88.0	151.0	67.0	22.8
Zambia 2007	70.0	119.0	57.7	40.8
Zambia 2001/02	95.0	168.0	58.7	34.2
Zambia 1996	109.0	197.0	59.5	25.9
Zimbabwe 2010/11	57.0	84.0	36.0	58.5
Zimbabwe 2005/06	60.0	82.0	38.1	60.2
Zimbabwe 1999	65.0	102.0	41.7	53.5
North Africa/West Asia/Europe				
Armenia 2010	13.0	16.0	21.7	54.9
Egypt 2008	25.0	28.0	35.0	-
Egypt 2005	33.0	41.0	40.0	-
Egypt 2000	44.0	54.0	47.9	-
Egypt 1995	63.0	81.0	54.5	-
Jordan 2009	23.0	28.0	57.6	-
Jordan 2007	19.0	21.0	59.8	-
Jordan 2002	22.0	27.0	61.3	-
Morocco 2003/04	40.0	47.0	46.9	63.0
Morocco 1992	57.0	76.0	64.3	41.5
Morocco 1987	74.0	103.0	66.3	35.9
Tunisia 1988	48.0	61.9	61.2	49.8
Turkey 1998	43.0	52.0	40.2	63.9
Turkey 1993	53.0	61.0	44.3	-
Ukraine 2007	14.0	17.0	14.9	66.7
Ukraine 1999	14.0	14.0	-	67.4
Central Asia				
Kazakhstan 1999	62.0	71.0	38.7	66.1
Kazakhstan 1995	40.0	45.0	38.7	59.1
Kyrgyz Republic 1997	61.0	72.0	43.3	59.5
Turkmenistan 2000	73.9	94.3	42.2	61.8
Uzbekistan 1996	49.1	59.3	42.7	55.6
South & Southeast Asia				
Bangladesh 2007	52.0	65.0	46.7	-
Bangladesh 2004	65.0	88.0	51.9	-
Bangladesh 1999/2000	66.0	94.0	53.0	-
Bangladesh 1996/97	82.0	116.0	57.8	-
Cambodia 2010	45.0	54.0	36.0	50.5
Cambodia 2005	66.0	83.0	46.6	40.0
India 2005-06	57.0	74.0	46.0	56.3
India 1998/99	68.0	95.0	50.6	-
Indonesia 2007	34.0	44.0	32.4	-
Indonesia 2002/03	35.0	46.0	34.0	-
Indonesia 1997	46.0	58.0	40.1	-
Indonesia 1994	57.0	81.0	45.0	-
Indonesia 1991	68.0	97.0	47.6	-
Nepal 2011	46.0	54.0	39.0	49.7
Nepal 2006	48.0	61.0	45.2	48.0
Nepal 2001	64.0	91.0	52.7	-

Pakistan 2006/07	78.0	94.0	61.5	-
Philippines 2008	25.0	34.0	50.6	50.7
Philippines 2003	29.0	40.0	53.5	48.9
Philippines 1998	35.0	48.0	56.9	47.8
Sri Lanka 1987	24.7	34.0	43.3	61.7
Thailand 1987	35.0	44.0	37.6	65.5
Vietnam 2002	18.0	24.0	34.8	75.3
Vietnam 1997	29.0	37.0	25.4	78.5
Latin America & Caribbean				
Bolivia 2008	50.0	63.0	53.0	60.6
Bolivia 2003	54.0	75.0	57.8	58.4
Bolivia 1998	67.0	92.0	59.0	48.3
Bolivia 1994	75.0	116.0	61.6	45.3
Brazil 1996	39.0	49.0	44.5	76.7
Brazil 1986	73.0	83.0	54.4	66.2
Colombia 2010	16.0	19.0	38.3	79.1
Colombia 2005	19.0	22.0	41.6	78.2
Colombia 2000	21.0	25.0	42.4	76.9
Colombia 1995	28.0	36.0	44.8	72.2
Colombia 1990	16.0	23.0	45.4	66.1
Colombia 1986	32.3	41.2	53.3	64.8
Dominican Republic 2007	32.0	37.0	42.9	72.9
Dominican Republic 2002	31.0	38.0	44.9	69.8
Dominican Republic 1999	22.0	30.0	44.2	69.2
Dominican Republic 1996	47.0	57.0	49.2	63.7
Dominican Republic 1991	43.0	59.0	50.2	56.4
Dominican Republic 1986	67.0	88.0	57.3	49.8
Ecuador 2004	30.0	35.0	-	72.7
Ecuador 1999	30.0	38.0	-	65.8
Ecuador 1987	57.0	80.9	58.5	44.3
El Salvador 2008	16.0	19.0	-	72.3
El Salvador 2002-03	25.0	31.0	-	66.9
El Salvador 1998	35.0	43.0	-	60.0
El Salvador 1985	67.0	85.0	60.2	47.3
Guatemala 2008/09	30.0	42.0	-	54.1
Guatemala 2002	39.0	53.0	-	43.3
Guatemala 1998/99	45.0	59.0	62.8	38.2
Guatemala 1995	51.0	68.0	65.1	31.4
Guatemala 1987	73.0	109.0	66.0	23.2
Haiti 2005/06	57.0	86.0	55.5	32.0
Haiti 2000	80.0	119.0	61.4	28.1
Haiti 1994/95	74.0	131.0	60.0	18.0
Mexico 1987	47.0	61.0	59.7	52.7
Nicaragua 2006/07	29.0	35.0	-	72.4
Nicaragua 2001	31.0	39.0	55.4	68.6
Nicaragua 1998	40.0	50.0	60.7	60.3
Paraguay 2008	20.0	23.0	-	79.4
Paraguay 2004	29.0	33.0	-	72.8
Paraguay 1995/96	27.0	34.0	-	55.9
Paraguay 1990	33.5	42.5	60.8	48.4
Peru 2007/08	19.0	27.0	42.4	72.4
Peru 2004/06	22.0	30.0	43.6	71.3
Peru 2000	33.0	47.0	48.3	68.9
Peru 1996	43.0	59.0	52.7	64.2
Peru 1992	54.0	78.0	56.4	59.0
Peru 1986	75.0	110.0	64.2	45.8
Trinidad & Tobago 1987	28.0	32.0	50.5	52.7

NOTES:
(a) Based on experience in the 5 years prior to the survey.
(b) Percent of married/in union women using any method.

Source: ICF International, 2012. MEASURE DHS+ STATcompiler. http://www.measuredhs.com, January 18, 2013.

7.3.5.2.4.4 Results

The results from the child survival component of FamPlan correspond to the items described in Child survival editor inputs. These appear for all years included in your FamPlan projection.

To examine the results of the projection, click on "Results" on the menu bar.

To see values for "Percent of births with any risk" click on "Fertility and FP use" then scroll down to the bottom.

To see value for "Risk-adjusted IMR" and "Risk-adjusted U5MR" click on "Mortality rates" from the results menu.

"Risk-adjusted" simply means that the projected IMR reflects its fixed relationship to the percentage of high-risk births, and similarly for the U5MR. Note that the actual mortality rates in the country may be different from this projection, since they also reflect the direct action of various health programs and special causes of deaths such as HIV/AIDS. The child survival component of FamPlan simply lets the user estimate the difference in future mortality rates due just to rising contraceptive use.

7.3.5.2.4.5 Sample applications

The following shows two alternative projections that run from 2000 to 2015, using an East African country for illustrative purposes. One advantage of a starting date in the past is that a national survey may be available to provide baseline data for the FamPlan application.

The following are the inputs, as of 2000, for three of the required items (default values, if available can be used for the additional items):

Percentage of high-risk births: 67%
Baseline IMR   102
Baseline U5MR   148

Since the child survival component for FamPlan starts from the projection for contraceptive use, the first display below gives the time trend under two assumptions for the possible rise in prevalence. Next comes the resulting change in the percentage of high-risk births, and then the corresponding infant and child mortality rate projections. As these charts indicate, a substantial difference in contraceptive use is paralleled by substantial improvements in high-risk births and in mortality.

Percent of births with any risk

Risk-adjusted IMR

Risk-adjusted U5MR
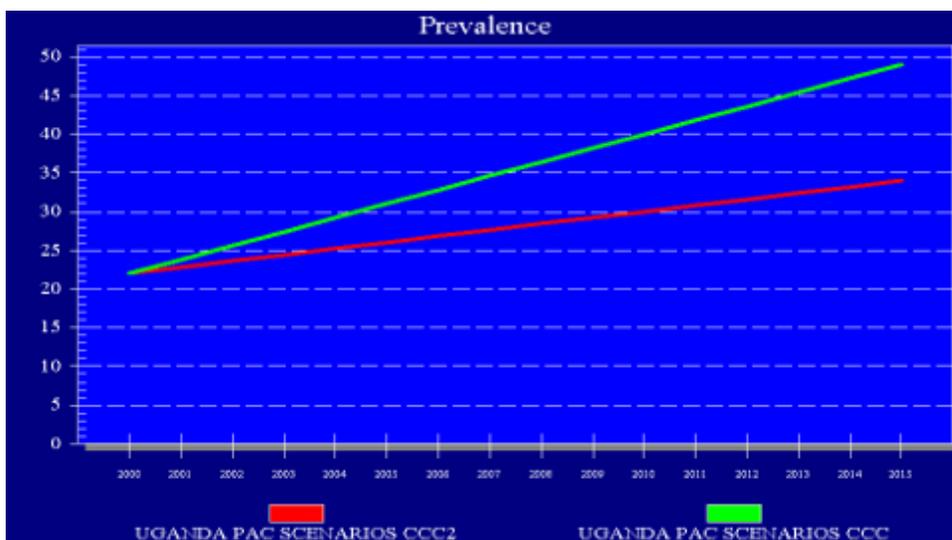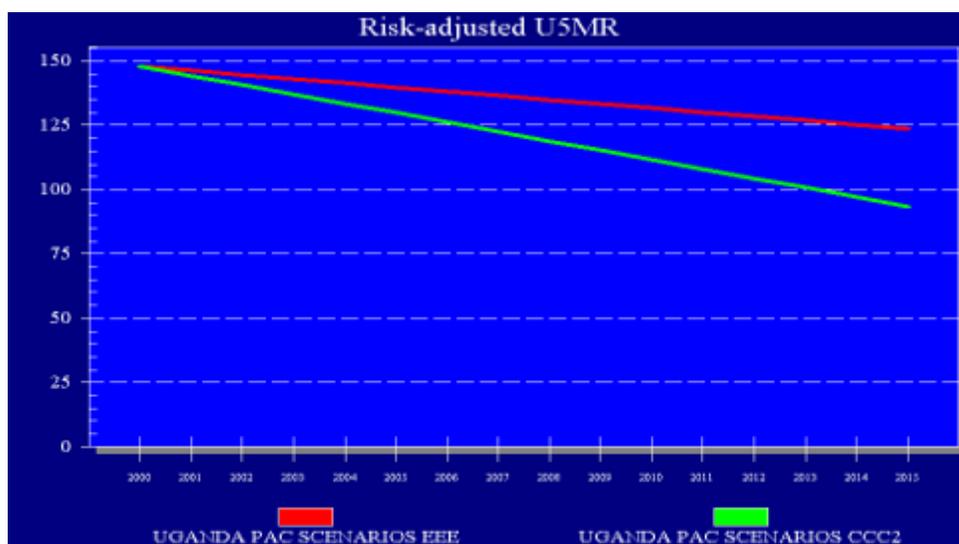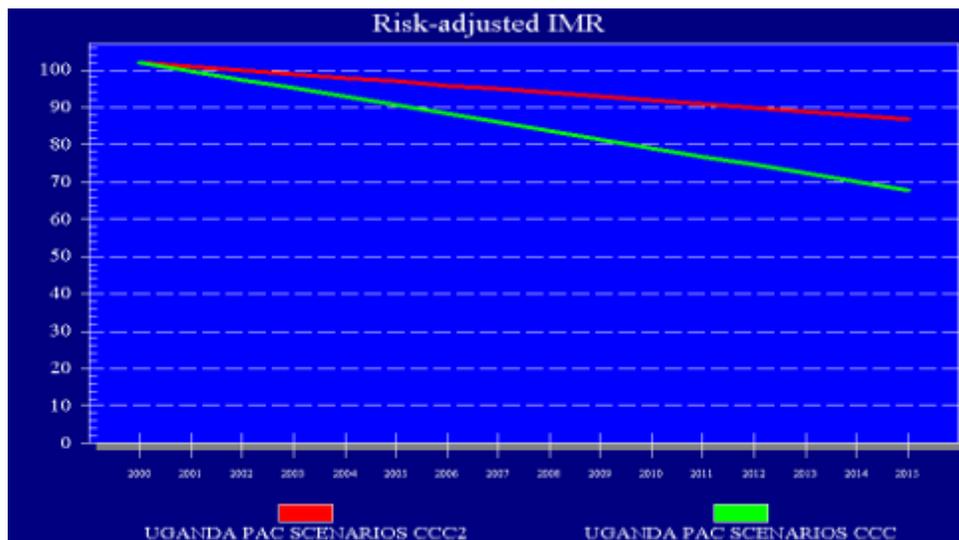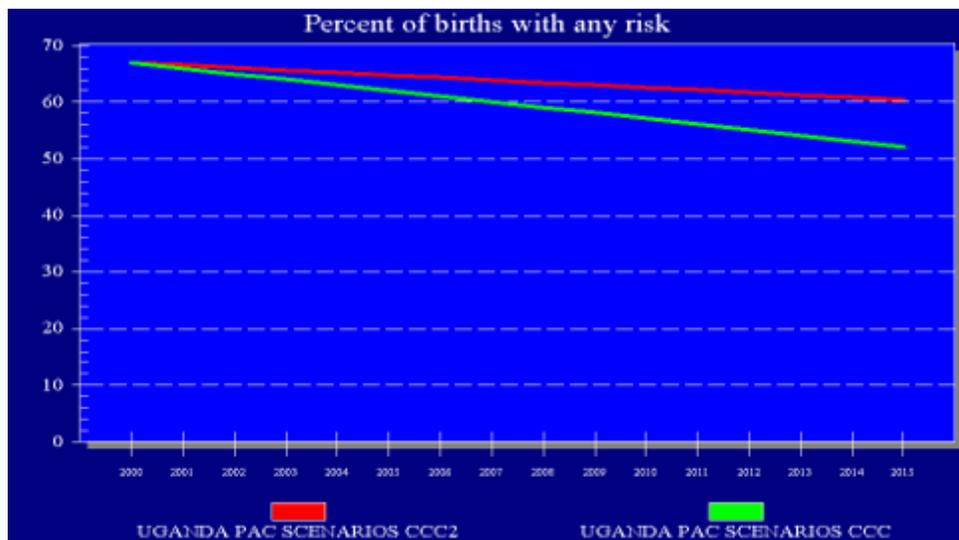
By the end of the projection period, in 2015, there is a difference of 15 points in prevalence. The corresponding differences in outputs are 9 points (14%) in the percentage of high-risk births, 20 points (22%) difference for the IMR, and 26 points (23%) for the U5MR.

The outputs also include the numbers of infant and child deaths that correspond to the projected IMR and U5MR rates.

Note: the user can convert these outputs to numbers of births and deaths, obtained them by going to the "Results" menu under "Demography (DemProj)," then "Vital Events," then "Births," or "Deaths by Age."

7.3.5.2.4.6 Methodology

The methodology and equations for the child survival component of FamPlan are relatively simple. First is the linkage from contraceptive prevalence to the percent of high-risk births. Then the percent of high-risk births is linked to the IMR and to the U5MR.

Default values are used for each of these three links, as shown in Equations 1-3 below. You may override these if you have reliable trend data from your own country.

The three links are established from international experience, in countries that have multiple surveys to show actual time trends. For the first link the following chart shows, for 36 countries, the past trends. The slopes vary, but the overall pattern is clearly an inverse one: over time, rising contraceptive use has been accompanied by fewer high-risk births. For example, as couples want smaller families they use contraceptive methods to avoid births at higher orders and later ages, as clearly documented in many national surveys, and such births carry elevated rates of infant and child deaths.

After considerable analysis we decided to use the median slope as the best single estimate of this first relationship. The median slope in the figure is -0.55, that is, a one point rise in prevalence is accompanied by 0.55 point fall in the percent of high-risk births. See Equation (1).
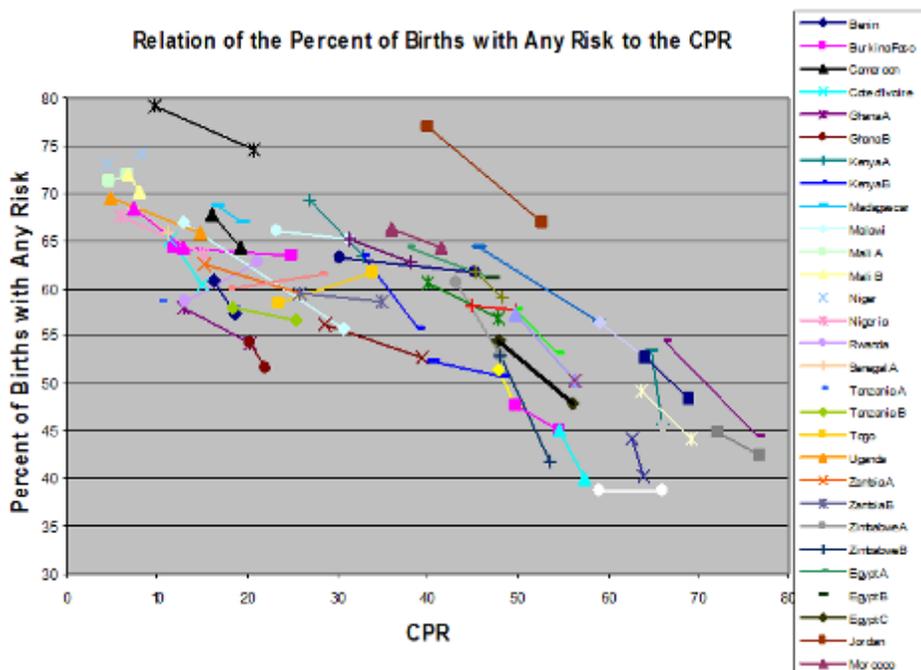
The second relationship, between high-risk births and the IMR, is shown in the next chart. Here the median slope is 2.31, that is, a one point fall in the percent of high-risk births is accompanied by a fall of 2.31 points in the IMR. See Equation (2).

Relation of the IMR to the Percent of Births with Any Risk
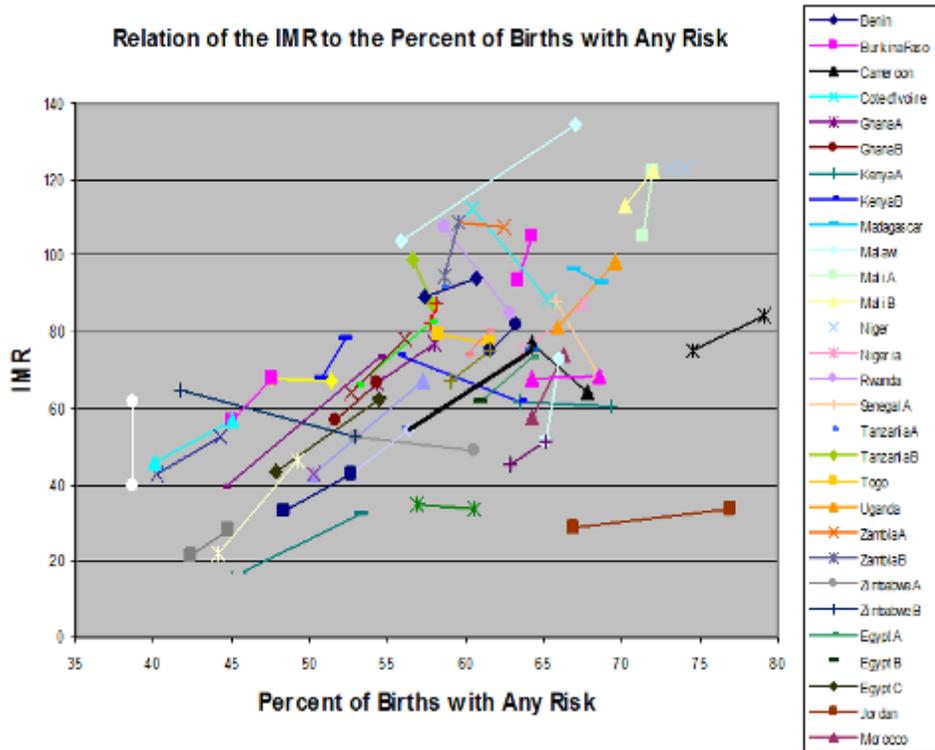
The third relationship, between high-risk births and the U5MR, appears in the following chart. The median slope is 3.54, that is, a one point fall in the percent of high-risk births is accompanied by a fall of 3.54 points in the U5MR. See Equation (3).

Relation of the U5MR to the Percent of Births with Any Risk
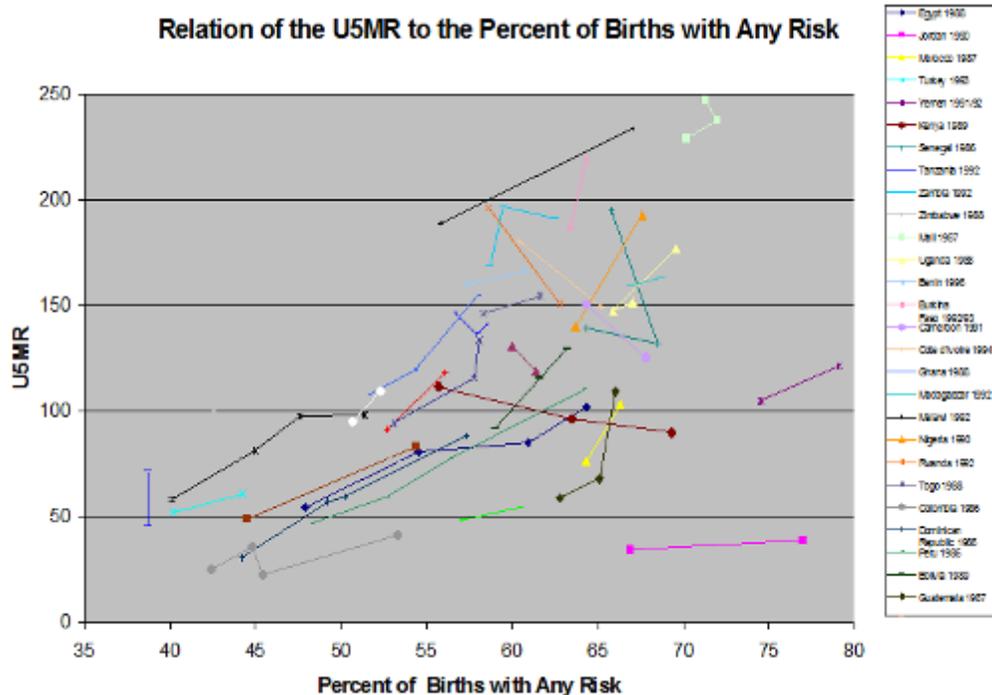
The equations follow. Note that they relate change to change: starting from the baseline values in the initial year for the various quantities, the values for each following year are determined just by the change from the baseline year. Let

R = percent of high risk births

IMR = infant mortality rate

U5MR = under five mortality rate

B = absolute number of births

DI = absolute number of infant deaths

DC = absolute number of child deaths

b = baseline year

t = projection year

Equation (1) $R_t = R_b - 0.55*(P_t - P_b)$
[to relate risky births to contraceptive use]

For example, suppose that in 2000, P_b is 25 and Rb is 60, and in 2010 P_t is 40, then in 2010 R_t will be:

$60 - 0.55*(40-25)$ or 51.75 for the percent of high-risk births, down from 60%.

Equation (2) $IMR_t = IMR_b - 2.31*(R_b-R_t)$
[to relate the IMR to risky births]

> For example, suppose that in 2000 R_b is 60 and IMR_b is 120, and in 2010 R_t is 51.75, then in 2010 IMR_t will be:
>
> 120 – 2.31 *(60-51.75) or 101 as the IMR in 2010, down from 120.

Equation (3) $U5MR_t = U5MR_b - 3.54*(R_b-R_t)$
[to relate the U5MR to risky births]

> For example, suppose that in 2000 R_b is 60 and U5MR is 145, and in 2010 R_t is 51.75, then in 2010 $U5MR_t$ will be:
>
> 145 – 3.54*(60-51.75) or 115 as the U5MR in 2010, down from 145.

Equation (4) $DI = B_t*IMR_t$
[to compute the number of infant deaths]

> For example suppose that in the base year there are 1,000,000 births and the IMR is 120. Then there will be 120,000 infant deaths.

Equation (5) $DC = B_t*U5MR_t$
[to compute the number of child deaths]

> For example suppose that in the base year there are 1,000,000 births and the U5MR is 145. Then there will be 145,000 child deaths.

7.3.5.2.5 Costs of services

Using the editor
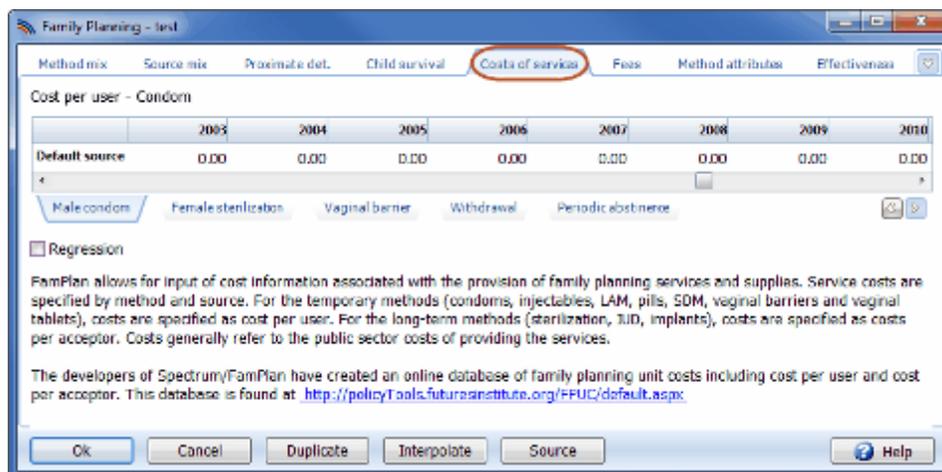
1. Scroll to the right or left to see all the years.

2. Enter the total public sector costs per user or acceptor for each source and each method, for all years (unless you plan to use the "Regression" feature, described just below). Select the methods from the tabs near the bottom of the editor, just like in the "Source Mix" editor. If a particular source is not available for some method, the cost may be left at zero.

FamPlan can project future costs per user using the relationship shown in **Figure 3**. To use this feature, click the check box marked "Regression" at the bottom of the edit screen for "Costs of Services" (just above the method tabs). Then enter the cost per user or acceptor for the first year for each method and source. The program will calculate the (eventual) declining cost per user or acceptor in the future as a function of increasing prevalence.

Cost information

FamPlan allows for input of cost information associated with the provision of family planning services and supplies. Service costs are specified by method and source. For the temporary methods (condoms, injectables, pills, vaginal barriers and vaginal tablets), costs are specified as cost per user. For the long-term methods (sterilization, IUD, Norplant), costs are specified as costs per acceptor. Costs generally refer to the public sector costs of providing the services.

A second input related to the total cost of services is the fee paid by users. This information is used to determine public sector revenues and net public sector costs.

Various estimates of the costs of family planning services have been made. Most of these studies estimate the annual expenditure on family planning rather than the costs (which would amortize capital investments over the lifetime of the capital goods). The World Bank compiled a set of estimates on expenditure per user in 1980 (Bulatao, 1985). These figures were calculated on the basis of estimates of per capita public expenditures on population programs in 1980 from various sources. Another set of data, prepared from figures submitted by governments on their family planning expenditures, was published in *Family Planning and Child Survival*   (Ross, 1988). Population Action International recently prepared estimates of family planning expenditures from all sources for 79 countries (Conly, Chaya, and Helsing, 1995). Since each of these studies used different approaches and different data sources, the results are not strictly comparable. However, they do provide the best picture available of the overall pattern of expenditure on family planning services. Several country-specific studies of family planning expenditure are available to supplement these three sources. The information on cost per user from the Population Action International study is shown in **Table 9**.

More detailed studies have been conducted for a small number of countries. The results of these studies are summarized in **Table 10**.

Determining the costs of family planning programs is not a simple exercise. No systematic series of surveys or reports exists to give easy access to method-specific costing data. Yet the use of reasonable costing data makes FamPlan an attractive tool for rationally planning a program's expansion or reconfiguration. The figures in Tables 9 and 10 are all methods and sources combined. Therefore, their utility will be in providing a reliability check against summary costs generated by a FamPlan application. Method- and source-specific figures are provided later in this section.

Table 9: Expenditures per Family Planning User (US Dollars)

Region	Cost per user	Region	Cost per user
Sub-Saharan Africa		**Asia**	
Benin	17.91	Afghanistan	14.58
Botswana	39.50	Bangladesh	15.12
Burkina Faso	26.07	China	6.38
Burundi	18.64	Hong Kong	17.42
Cameroon	12.40	India	4.59
Central African Republic	17.97	Indonesia	12.66
Chad	5.71	Iran	11.00
Congo	13.55	Malaysia	12.89
Cote d'Ivoire	56.10	Mongolia	6.36
Ethiopia	14.17	Nepal	8.18
Gabon	1.39	Pakistan	18.19
Ghana	23.73	Papua New Guinea	116.43
Guinea	45.39	Philippines	7.11
Guinea-Bissau	16.78	Singapore	4.33
Kenya	17.92	South Korea	6.19
Lesotho	92.02	Sri Lanka	9.36
Liberia	33.77	Taiwan	15.28
Madagascar	8.02	Thailand	5.29
Malawi	19.63	Vietnam	2.51
Mali	69.07	**Latin America and Caribbean**	
Mauritania	99.64		
Mauritius	12.67	Bolivia	23.39
Mozambique	8.80	Brazil	7.66
Niger	96.60	Colombia	7.57
Nigeria	15.15	Costa Rica	25.19
Rwanda	45.34	Dominican Republic	8.61
Senegal	61.52	Ecuador	18.79
Sierra Leone	6.87	El Salvador	18.17
South Africa	17.92	Guatemala	32.81
Sudan	7.63	Haiti	42.47
Tanzania	17.00	Honduras	21.29
Togo	30.11	Jamaica	19.49
Uganda	42.11	Mexico	13.08
Zaire	9.16	Nicaragua	16.40
Zambia	13.18	Panama	17.31
Zimbabwe	14.71	Paraguay	11.89
		Peru	5.39
North Africa and Near East		Trinidad and Tobago	14.15
Algeria	10.28		
Egypt	8.92		
Jordan	20.31		
Morocco	13.96		
Tunisia	27.24		
Turkey	8.88		
Yemen	38.59		

Source: Conly, Chaya, and Helsing, 1995.

Table 10: Government Expenditure per Family Planning User (US Dollars)

Country	Year	Expenditure per User	Data Source
Bangladesh	1991	14.10	1
Ecuador	1994	11.22	1
Ghana	1993	25.06	1
Jamaica	1990	35.51	2
Kenya	1993	25.03	3
Thailand	1988/89	13.34	4

Sources: 1. Thompson and Janowitz, 1996 a through c; 2. Scott and Kocher, 1992; 3. Abel, 1995; 4. Leoprapai et al., 1991.

As **Table 10** illustrates, there is considerable variation by country, year, and source of data. Much of this variation is clearly due to the difficulty of estimating total expenditures and to differences among definitions used by those preparing the estimates.

Figure 4 presents the results of a regression analysis that illustrates the relationship between expenditure per user and contraceptive prevalence. In this figure, observations from **Table 9** are plotted versus total prevalence. The smooth curve depicts the inverse relationship between expenditure per user and prevalence. The equation for this curve is:

$$\text{Expenditure/user} = 10.51 + \frac{240.68}{\text{prevalence}}.$$

This figure illustrates that cost per user may decline as prevalence increases. This fact seems to suggest an economy of scale or efficiency gained as prevalence increases. This relationship should be considered for projecting cost per user or acceptor into the future.

Figure 4: Relationship Between Expenditure per User and Contraceptive Prevalence
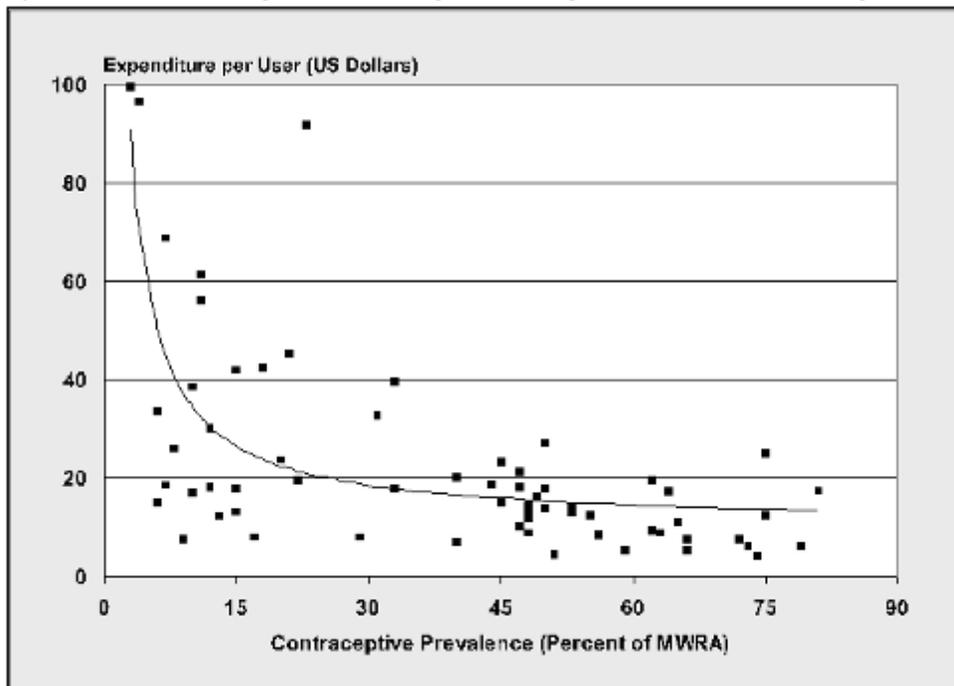
The figures on aggregate expenditure per user vary significantly from country to country. Some of this variation is due to different cost structures and differences in implementation approach. Some of the

variation is due to different source and method mixes. An indication of how cost may vary by source is given in **Table 11**.

Table 11: Cost per CYP by Source of Family Planning (U.S. Dollars)

Country	Cost per CYP
Full Clinic	
Colombia	1.80
Ghana	11.58
India	3.29
Indonesia	14.83
Mexico	1.90
Thailand	6.74
Weighted Average	**3.89**
Full Clinic with Community-Based Distribution	
Bangladesh	14.91
Brazil	3.61
Mexico	5.78
Morocco	9.03
Nigeria	6.17
Weighted Average	**14.00**
Clinic Without Sterilization	
Brazil	5.65
Colombia	6.69
Egypt	4.46
India	6.21
Kenya	4.27
Morocco	9.38
Zimbabwe	19.57
Weighted Average	**6.10**
Sterilization Clinic	
Colombia	0.24
India	1.88
Weighted Average	**1.85**
Community-Based Distribution	
Egypt	3.73
Indonesia	5.00
Kenya	24.34
Mexico	27.21
Zimbabwe	14.96
Weighted Average	**9.93**
Social Marketing	
Bangladesh	1.96
Colombia	Profit
Egypt	2.03
Ghana	7.86
India	2.15
Indonesia	1.32
Mexico	1.58
Morocco	15.39
Nigeria	14.51
Zaire	13.53
Zimbabwe	15.89
Weighted Average	**2.14**

Source: Barberis and Harvey, 1997.

Costs also vary by method. Several studies have examined costs by method and reported these costs on either a per-procedure or a per-visit basis. Tables 12 through 18 present data collected from various sources. Not surprisingly, cost differentials exist even in the same country. These data are not strictly comparable since different definitions of cost have been used, but they do serve to illustrate the range of costs that is experienced in programs today.

Table 12: Costs of Female Sterilization Procedures

Country	Date	Cost per Sterilization (US$)	Cost per CYP (US$)	Source
Bangladesh	1985	98.00	–	1
Bangladesh, public sector	1993	19.73	–	2
Colombia	1985	31.42	–	3
Colombia	1990	126.97	18.90	4
Dominican Republic	1990	–	5.14	5
Ecuador	1995	33.65	–	6
Guatemala	1983/84	68.00	–	1
Haiti	1986	300.00	–	7
Honduras	1988	96.00-101.00	–	1
Honduras, rural	1994	37.04	–	8
Honduras, urban	1994	39.76	–	8
Indonesia	1987	42.76	–	9
Indonesia	1988	37.00	–	1
Kenya, public sector	1993	96.34	–	10
Latin America, private sector	1985	50.00-666.00	–	11
Mexico, rural clinic	1988	40.00	–	12
Mexico, urban hospital	1988	173.00	–	12
Morocco	1986	133.00	–	1
Thailand	1988/89	48.75	5.25	13

Sources: 1. Janowitz, Bratt, and Fried, 1990; 2. PDEU, Bangladesh, 1996 a and b; 3. Jaramillo et al. 1986; 4. Bratt, 1992; 5. Janowitz and Bratt, 1992; 6. Thompson and Janowitz, 1996 a through c; 7. Bogue, 1986; 8. Dmytraczenko, 1997; 9. PKMI, 1988; 10. Abel, 1995; 11. Lewis, 1985; 12. Nortman and Tsui, 1989; 13. Leoprapai et al., 1991.

Table 13: Costs of Male Sterilization Procedures

Country	Date	Cost per Sterilization (US$)	Cost per CYP (US$)	Source
Bangladesh, public sector	1993	12.28	–	1
Colombia, male-only clinics	1988/89	127.86	10.22	2
Colombia, mixed clinics	1988/89	152.95	12.23	2
Thailand	1988/89	45.79	5.88	3

Sources: 1. PDEU, Bangladesh, 1996 a and b; 2. Vernon, Oheda, and Vega, 1991; 3. Leoprapai et al., 1991.

Table 14: Costs of IUD Insertion

Country	Date	Cost per Insertion (US$)	Cost per CYP (US$)	Source
Bangladesh, NGO clinics	1993	2.27	4.14	1
Bangladesh, outreach	1985	18.00	–	2
Bangladesh, public sector clinics	1993	2.00-3.00	4.56	1
Colombia	1990	13.75	17.07	3
Haiti	1986	40.00	–	4
Honduras	1988	11.00	–	2
Honduras, rural	1994	10.00	–	5
Honduras, urban	1994	8.91	–	5
Kenya	1993	26.73	–	6
Mexico, NGO clinics	1993	4.24	–	7
Mexico, rural	1989	10.00-13.00	–	8
Mexico, urban	1989	18.00-24.00	–	8
Philippines	1984	9.00	–	2
Thailand	1989	10.00	–	2
Thailand	1990/91	2.64	4.07	9
Thailand, public sector	1988/89	18.44	8.25	10

Sources: 1. PDEU, Bangladesh, 1996 a and b; 2. Janowitz, Bratt, and Fried, 1990; 3. Bratt, 1992; 4. Bogue, 1986; 5. Dmytraczenko, 1997; 6. Abel, 1995; 7. Suárez and Brambila, 1994; 8. Nortman and Tsui, 1989; 9. Janowitz et al., 1994; 10. Leoprapai et al., 1991.

Table 15: Costs of Oral Contraceptive Delivery

Country, by Type of Distribution	Date	Cost per Acceptor Visit (US$)	Cost per CYP (US$)	Source
Clinic/Health Center				
Bangladesh, NGO	1993	0.85	5.67	1
Bangladesh, public sector	1993	1.00	6.52	1
Honduras	1988	7.63	31.15	2
Honduras, urban	1994	4.97	–	3
Honduras, rural	1994	5.04	–	3
Mexico, urban	1989	8.80	22.00	4
Mexico, rural	1989	1.73	6.00	4
Morocco, urban	1987	–	7.40-34.10	5
Morocco, rural	1987	–	24.74-30.29	5
Philippines	1984	7.57	21.09	2
Thailand	1988	4.38	18.62	2
Community-Based Distribution				
Bangladesh, NGO	1993	–	6.77	1
Bangladesh, public	1993	–	5.86	1
Colombia	1984-86	–	13.79	2
Colombia	1990	0.85	12.76	6
Dominican Republic	1990	–	8.82	7
Honduras	1988	–	18.47	2
Mexico	1989	–	11.00	4
Peru	1986-87	–	6.18	2
Social Marketing				
Bangladesh	1985	–	5.62	2
Colombia	1984-86	–	4.69	2
Colombia	1990	0.63	9.45	6
Dominican Republic	1990	–	2.50	8
Dominican Republic	1990	–	6.53	6
Ecuador	1990	–	11.30	8
Ghana	1990	–	4.10	8
Honduras	1989	–	11.94	2
Indonesia	1990	–	1.10	8
Zimbabwe	1990	–	11.40	8
Unspecified Distribution Type				
Thailand, public	1988/89	7.70	6.54	9

Sources: 1. PDEU, Bangladesh, 1996 a and b; 2. Janowitz, Bratt, and Fried, 1990; 3. Dmytraczenko, 1997; 4. Nortman and Tsui, 1989; 5. Knowles and Emrich, 1989; 6. Bratt, 1992; 7. Janowitz and Bratt, 1992; 8. Stover and Wagman, 1991; 9. Leoprapai et al., 1991.

Table 16: Costs of Condom Delivery

Country	Date	Cost per Visit (US$)	Cost per CYP (US$)	Source
Clinic				
Bangladesh, public	1993	1.00-2.00	–	1
Bangladesh, NGO	1993	1.11	–	1
Social Marketing				
Bangladesh	1985	–	6.55	2
Barbados	1990	–	11.80	3
Colombia	1990	0.23	34.13	4
Dominican Republic	1990	–	5.90	3
Dominican Republic	1990	–	23.62	5
Ghana	1990	–	6.10	3
Honduras	1989	–	14.77	2
Indonesia	1990	–	1.10	3
Mexico	1990	–	3.80	3
Zimbabwe	1990	–	12.70	3
Community-Based Distribution				
Bangladesh, NGO	1993	–	7.25	1
Bangladesh, public	1993	–	7.18	1
Colombia	1990	0.49	73.02	4
Dominican Republic	1990	–	50.53	5
Honduras	1988	–	21.72	2
Outreach				
Bangladesh	1985	–	11.01	2
Unspecified Distribution Type				
Thailand, public	1988/89	8.87	9.65	6

Sources: 1. PDEU, Bangladesh, 1996 a and b; 2. Janowitz, Bratt, and Fried, 1990; 3. Stover and Wagman, 1991; 4. Bratt, 1992; 5. Janowitz and Bratt, 1992; 6. Leoprapai et al., 1991.

Table 17: Costs of Injectable Delivery

Country	Date	Cost per Acceptor Visit (US$)	Cost per CYP (US$)	Source
Hospital				
Thailand	1990/91	1.45	5.17	1
Clinic				
Bangladesh, NGO	1993	1.49	7.98	2
Bangladesh, gov	1993	–	8.52	2
Unspecified Distribution Type				
Thailand, public	1988/89	10.23	10.70	3

Sources: 1. Janowitz et al., 1994; 2. PDEU, Bangladesh, 1996 a and b; 3. Leoprapai et al., 1991.

Table 18: Costs of Implant Procedures

Country	Date	Cost per Acceptor Visit (US$)	Cost per CYP (US$)	Source
Hospital				
Thailand	1990/91	25.47	28.18	1
Clinic				
Colombia	1990	62.76	31.55	2
Unspecified Distribution Type				
Thailand, public	1988/89	59.45	–	3

Sources: 1. Janowitz et al., 1994; 2. Bratt, 1992; 3. Leoprapai et al., 1991.

If country-specific estimates of the costs of family planning are not available and cannot be developed with the time and resources available, it is possible to make a rough estimate of costs using the information in the tables presented above. The information in these tables indicates that costs are likely to be in the ranges shown in **Table 19**.

Table 19: Ranges of Cost by Method

Method	Cost
Female sterilization	$ 30-100 per procedure
IUD	$ 9-20 per insertion
Orals	$ 6-34 per CYP for clinics
	$ 6-18 per CYP for community-based distribution
	$ 4-12 per CYP for social marketing
Condoms	$ 6-20 per CYP
Injectables	$ 5-11 per CYP
Implant	$ 25-60 per implant

[1] Expenditure figures in Table 10 and Tables 12 through 18 are from various years and sources and are not adjusted for inflation.

7.3.5.2.6 Fees

Using the editor

1. Scroll to the right or left to see all the years.

2. Enter any fees associated with method-specific services by source. Note that the fee unit changes with each method. It is shown in the title just above the edit tables (e.g., Fee per condom?Condom, Fee per operation?Female sterilization, Fee per injection?Injectable, etc.).

Note that since most projections define the costs to be public sector costs, the fees should be those fees that accrue to the public sector. Thus, for condoms sold by pharmacies with no public sector subsidy, the costs and fees for condoms provided by pharmacies would generally be set to zero. However, for a community-based distribution (CBD) program that does receive public sector subsidies, the public sector costs and fees should be specified.

A second input related to the total cost of services is the fee paid by users. This information is used to determine public sector revenues and net public sector costs.

7.3.5.2.7 Method attributes

Using the editor

1. Scroll to the right or left to see all the years.

2. For each year of the projection, only those methods chosen in the Configuration screen will be shown. Enter the units per CYP for the temporary methods (Condoms, Injections, Pill cycles and Vaginal tablets), the average duration of use for the long-term methods (IUD and Norplant), and the average age at sterilization for the permanent methods (male and female sterilization). The model contains default values that can be used for most methods. However, the age at sterilization should be changed to reflect the actual program situation.

Characteristics of method practice

"Method attributes" refers to the characteristics of method practice that are needed to calculate the number of users, acceptors and commodities required to meet the chosen goals. For the temporary methods (condoms, injections, pills, LAM, SDM and vaginal tablets), the key attribute is couple-years of protection, or CYP (defined below). The connection between the method used and the goal sought is in terms of the protection given to couples against unintended pregnancy. For the longer-term methods (IUD and implants), the key attribute is the average duration of use. For the permanent methods (female and male sterilization), the duration of use is determined from the average age at the time of sterilization.

Commodity Units per CYP

FamPlan calculates the commodity consumption needed to achieve the family planning goal. For the temporary methods (condoms, injections, pills and vaginal tablets) the commodities needed are calculated from the number of units required to provide one couple-year of protection. One CYP is the protection required by one couple using a contraceptive method for an entire year.

For temporary hormonal methods, the number of units per CYP is determined by the recommended usage pattern and by any wastage that occurs. Theoretically, one CYP requires 13 cycles of pills or four injections of Depo-Provera or six injections of Noristerat, since these are the amounts required to protect one woman for an entire year. The actual number of units per CYP may be larger than this theoretical number because of wastage. For injectables, this wastage factor is likely to be small since it depends only on the clinical warehousing and distribution system. For pills the wastage factor could be considerably higher, particularly when pills are provided free.

For coitus-dependent methods (condoms and vaginal tablets), the number of units per CYP depends on the frequency of coitus and on wastage.

In 1997, USAID revised its recommended CYP factors based on a comprehensive study by the EVALUATION Project (Stover et al., 1997). These recommendations for the temporary methods are shown in **Table 5**.

Table 5: Standard Values of Commodity Units per CYP for Temporary Methods

Method	Units per CYP
Oral contraceptives	15 cycles
Condoms	120 condoms
Vaginal foaming tablets (VFTs)	120 tablets
Depo-Provera (injectable)	4 doses
Noristerat (injectable)	6 doses

Source: Stover et al., 1997. Also Stover et al., 2000.

Average Duration of Use

For the long-term methods (IUD and Implant), the average duration of use determines the number of new acceptors (and thus the service requirements) required to achieve a certain number of users or method prevalence. Information on the average duration of use for the IUD is available from some DHS studies, from randomized clinical trials, and from follow-up studies. Stover et al. (1997) concluded that the average duration of use for IUDs is about 3.5 years. Since very little country-specific data are available, this figure is recommended for most countries.

The EVALUATION Project also reviewed information on duration of use of implants such as Norplant. Data are available from 11 countries. The recommended figure for average duration of use for Norplant is 3.5 years.

Average Age of Users

The single-age-group version of FamPlan does not require any age-specific information. All inputs such as "percent in union" and "percent using a method" refer to the entire group of women of reproductive age. Age-specific information is required only in the calculation of the number of users of each method who age out of the reproductive years. In practice, this calculation is only significant in the case of male and female sterilization. In this case, FamPlan estimates the percentage of users of each method who are aged 45-49 from the average age at the time of sterilization.

Aging out of the reproductive years is significant to a family planning model because the protection given by a long term contraceptive method becomes moot after menopause. An IUD may be maintained in place, and of course a sterilization doesn't become reversed. But these methods no longer protect against pregnancy. The younger a couple is at the time a procedure is performed, then the more years of actual protection are given before such protection is no longer relevant.

The average age at the time of sterilization is usually available from service statistics or national surveys. **Table 6** shows the average age at the time of female sterilization for a number of countries.

Table 6: Average Age at Sterilization

Country/Region	Median	Country/Region	Median
Sub-Saharan Africa		**Asia**	
Kenya 2008/9	33.0	Bangladesh 2007	26.9
Malawi 2010	33.3	Cambodia 2010	31.7
Namibia 2006/7	33.2	India 2005/6	26.0
South Africa 2003	32.4	Indonesia 2007	32.8
Tanzania 2010	35.0	Nepal 2011	27.0
Uganda 2011	33.4	Pakistan 2006/7	31.9
Zambia 2007	33.7	Philippines 2008	30.8
Zimbabwe 2005/6	33.9		
North Africa/West Asia/Europe		**Latin America & Caribbean**	
Armenia 2010	31.0	Bolivia 2008	32.5
Egypt 2008	34.0	Colombia 2010	29.4
Jordan 2009	36.5	Dominican Rep. 2007	28.0
Moldova 2005	31.0	Ecuador 2004	30.3
Morocco 2003/4	33.3	El Salvador 2002/03	26.0
Turkey 2003	31.6	Guatemala 2002	28.6
		Haiti 2005/6	33.0
		Honduras 2005/6	29.0
		Paraguay 2004	31.2
		Peru 2011	32.0

Sources: Demographic and Health Surveys (DHS) and surveys conducted by the Centers for Disease Control and Prevention (CDC)

Note: Medians are presented here since mean values are unavailable; however means would be nearly the same since the age range is limited and does not include extreme values.

7.3.5.2.8 Effectiveness

Using the editor

1. Scroll to the right or left to see all the years.

2. The model contains default values which are recommended for most projections; if these are not appropriate for this particular projection, make any changes necessary.

Method effectiveness

As used in FamPlan, method effectiveness is the proportion of users who do not become pregnant during a year of method use. For each method used in FamPlan, it is necessary to specify an average effectiveness rate, or the extent by which the practice of a method of contraception lowers fecundability. It is determined by both a population's ability to conceive and the extent of contraceptive method failure.

The EVALUATION Project recently reviewed a large number of studies of method effectiveness (Stover et al., 1997). That study found that method failure rates ranged from about 4 to 20 percent for the pill, 1 to 8 percent for the IUD and 11 to 40 percent for barrier methods. Failure rates for Norplant and injectables were found to be nearly zero. Based on these results, the recommended effectiveness rates for use in FamPlan are shown in **Table 7**. While the method failures normally do not make a large demographic impact, they can constitute a significant proportion of pregnancies at a given time.

Table 7: Effectiveness of Contraceptive Methods

Method	Effectiveness
Pill	92%
IUD	96%
Barrier methods	81%
Withdrawal or rhythm	50%
Norplant	100%
Injectable	100%
Sterilization	100%

Source: Stover et al., 1997. Also Stover et al., 2000.

7.3.5.3 Goal

7.3.5.3.1 Reducing unmet need for contraception

Using the editor

1. **Percent of unmet need that is satisfied.** In the third portion of this dialogue box, enter the percent of unmet need that will be satisfied for each year of the projection. In many cases it will be sufficient to enter a goal for the final year of the projection and interpolate from zero in the first year.

2. **Prevalence and unmet need in the base year.** In the first column of this section, enter the contraceptive prevalence in the base year. (Prevalence may be disaggregated by prevalence for spacing and prevalence for limiting if that option was selected under Configuration. This choice is not shown on this screen.) Information on contraceptive prevalence is usually available from fertility surveys. In the second column, enter the base year estimate of unmet need.

3. **The total fertility rate in the base year**. Enter the TFR in the base year in the edit box in middle of the screen.

To state the goal of the family planning program, this approach follows the recommendations of the 1994 International Conference on Population and Development. It allows you to specify the current use of contraception and the unmet need for contraception. Unmet need is concerned with exposure to an unintended pregnancy. As such, the concept includes both the current exposure to pregnancy and the

wishes of a woman. To be at risk of a pregnancy, a woman needs to be in a relationship, be neither currently pregnant nor amenorrheic as a result of a recent pregnancy, be fertile and pre-menopausal, and not be using contraception. Fertility preferences are equally important. Women with an unmet need are those who are at risk of pregnancy and either want no more children or want no children in the next two years. In sum, unmet need refers to couples who should logically be using contraception based on their fertility desires and susceptibility to a pregnancy, but for some reason are not using contraception.

There are three main categories of women who are classified as having an unmet need for contraception:
1. women who do not want another birth soon, but are exposed to the risk of pregnancy and are not using any method of contraception;
2. women who have had a recent birth that was unintended or mistimed and did not use contraception to try to prevent that pregnancy;
3. women who are currently pregnant but either did not intend the current pregnancy or did not want it at this time and were not using contraception to try to prevent it. Estimates of unmet need are available from most fertility surveys.

Unmet need is often expressed as unmet need for spacing and for limiting. Unmet need for spacing refers to those women who say that they want more children in the future, but not within the next two years. Unmet need for limiting refers to those women who say they do not want any more children.

To use this goal with FamPlan, you specify the net percentage of current unmet need that will be converted to contraceptive use by some time in the future. This amount of unmet need is added to current prevalence to determine the required prevalence in the future. Calculations may be done separately for spacing and limiting or for both types of need combined.

For example, assume that the prevalence of contraception is currently 20 percent. Also assume that the unmet need for contraception is measured at 10 percent. If you specify that 50 percent of unmet need should be met by the year 2000, then prevalence in the year 2000 would be set at 25 percent (20 percent current prevalence plus one-half of unmet need).

Of course, reality is more complicated. During the projection period, some people who are currently using contraception will stop. Some people with an unmet need will start using while others will not. Some people who currently have no need for contraception will become users during the projection period. Finally, people will move in and out of the unmet need category during the projection period as their situation changes. Even if 100 percent of current unmet need is satisfied by some future year, new unmet need may be created as fertility desires change, so that unmet need will not necessarily drop to zero.

This approach is not intended to suggest that prevalence will increase in the future simply by having more people with an unmet need start using contraception. However, this approach is a useful way for programs to think about the future when making projections of resource requirements, since it is grounded in current use and one measure of current need for contraception.

7.3.5.3.2 Total wanted fertility

Using the editor

1. **Percent reduction between actual and desired TFR.** Enter the percent reduction in the base year difference between the actual TFR and the desired TFR for each year of the projection. If the difference is 100 percent in some year, then the TFR will equal the desired TFR in that year. In many cases it will be sufficient to enter a goal for the final year of the projection and interpolate from zero in the first year.

2. **Base year values for the contraceptive prevalence and TFR.** Enter the contraceptive prevalence rate and the total fertility rate in the base year.

3. **Wanted TFR.** Enter the wanted total fertility rate.

To state the goal of the family planning program, one alternative is to specify the current level of the total fertility rate and the desired fertility rate and then to set a goal in terms of how quickly the desired fertility rate can be achieved. The desired fertility rate, also called the wanted total fertility rate, is an indicator similar to the total fertility rate. It indicates the average number of children that a woman would have *if her expressed fertility desires were achieved*. The wanted total fertility rate is calculated as the level of fertility that would have prevailed during the past few years if all unintended births had been prevented. Unintended births are defined as those births which would cause the number of surviving children to a woman to exceed her stated desired family size.

To choose this option in FamPlan, users specify the percent reduction in the difference between the actual TFR and the desired TFR by some future year. In this case, the future TFR is determined and FamPlan calculates the required prevalence to achieve this goal.

For example, suppose the current TFR is 5.0 and the desired TFR is 4.0. If the goal were to reduce the difference between the two by 50 percent by 2000, then the TFR goal for 2000 would be calculated to be 4.5.

7.3.5.3.3 Reaching a goal for contraceptive prevalence

Spectrum editor

1. **Prevalence.** Enter the goal level of contraceptive prevalence. This series should start with the actual prevalence in the base year of the projection. In many cases, it will be sufficient to enter a goal for the final year of the projection and interpolate from the actual value in the first year. Prevalence may be disaggregated by prevalence for spacing and prevalence for limiting if that option was selected under Configuration. This choice is not shown on this screen.

2. **Total fertility rate.** Enter the TFR in the base year.

In this approach, a contraceptive prevalence goal for the future is set. Certainly when setting this goal, the analyst should take into account the current prevalence as well as the amount of unmet need and the proportion of women who say they intend to use contraception in the near future. Contraceptive goals may also be based on rules of thumb (i.e., the most successful programs increase prevalence by about two percentage points per year).

A family planning projection may require an assumption about contraceptive prevalence if the goal is to achieve a certain level of prevalence or to meet unmet need. (For other goals, contraceptive prevalence is calculated as an output of the projection.)

Contraceptive prevalence consists of the percentage of women of reproductive age who are in union and who use contraception. Estimates of prevalence are usually derived from national surveys, including the DHS. Recent estimates of contraceptive prevalence are given for over 150 countries in **Table 3**. Prevalence may be further disaggregated to use of contraception for spacing and limiting. These categories are constructed from survey questions that ask respondents whether they want any more children and, if so, when they want them. Those who are using contraception and report that they want no more children are classified as using contraception for limiting. Those who are using contraception and report that they do want more children but not right away are classified as using contraception for spacing.

Table 3: Contraceptive Prevalence of Women in Union by Year of Survey

Table 3: Contraceptive Prevalence of Women in Union by Year of Survey

Country	Prevalence	Year	Country	Prevalence	Year
AFRICA	28.6	2009	Nigeria	14.6	2008
Eastern Africa	28.4	2009	Senegal	11.8	2005
Burundi	9.1	2005/6	Sierra Leone	8.2	2008
Eritrea	8.0	2002	Togo	16.8	2006
Ethiopia	14.7	2005			
Kenya	45.5	2008/9	**ASIA**	66.2	2009
Madagascar	39.9	2008/9	**Eastern Asia**	**82.8**	2009
Malawi	41.0	2006	China	84.6	2006
Mauritius	75.8[a]	2002	China, Hong		
Mozambique	16.5	2003/4	Kong SAR	79.5	2007
Rwanda	36.4	2007/8	D.R. Korea	68.6	2002
Uganda	23.7	2006	Japan	54.3[a,e]	2005
Zambia	40.8	2007	Mongolia	66.0	2005
Zimbabwe	60.2	2005/6	Rep. of Korea	80.0[e]	2009
			Central Asia	**56.8**	2009
			Kazakhstan	50.7	2006
			Kyrgyzstan	47.8	2005/6
Middle Africa	**18.6**	2009	Tajikistan	37.1	2007
Cameroon	29.2	2006	Turkmenistan	61.8	2000
Central Afr. Rep.	19.0	2006	Uzbekistan	64.9	2006
Chad	2.8	2004			
D.R. Congo	20.6	2007	**Southern Asia**	**53.9**	2009
Sao Tome and	38.4	2008/9	Afghanistan (E)	18.6[a,e]	2006
Principe			Bangladesh	55.8	2007
			Bhutan	30.7	2000
			(all women)		
			India	56.3	2005/6
Northern Africa	**50.4**	2009	Iran	73.3[e]	2002
Algeria	61.4	2006	Maldives	34.7[b]	2009
Egypt	60.3	2008	Nepal	48.0	2006
Libya	63.0	2003/4	Pakistan	27.0	2007/8
Morocco	63.0	2003/04	Sri Lanka	68.0[b,n,i]	2006/7
Sudan (northern)	7.6	2006			
			South Eastern		
Tunisia	60.2	2006	Asia	**62.2**	2009
			Cambodia	40.0	2005
Southern Africa	**58.4**	2009	Indonesia	61.4	2007
Lesotho	47.0[b]	2009	Laos	32.2	2000
Namibia	55.1	2006/7	Philippines	50.7	2008
South Africa	59.9	2003/4	Thailand	81.1	2006
Swaziland	50.6	2006/7	Timor-Leste	22.3[b]	2009/10
			Viet Nam	79.0	2007
Western Africa	**14.4**	2009			
Benin	17.0	2006			
Burkina Faso	17.4	2006			
Cape Verde	61.3	2005	**Western Asia**	**55.1**	2009
Côte d'Ivoire	12.9	2006	Armenia	53.1	2005
Ghana	23.5	2008	Azerbaijan	51.1	2006
Guinea-Bissau	9.1	2005	Georgia	47.3[e]	2005
Liberia	11.4	2007	Iraq	49.8	2006
Mali	8.2	2006	Jordan	59.3	2009
Mauritania	9.3	2007			
Niger	11.2	2006			

Lebanon	58.0	2004
Oman	31.7	2000
Qatar	43.2[s]	1998
Saudi Arabia	23.8[c,s]	2007
Syria	58.3	2006
Turkey	73.0	2008
Yemen	27.7	2006

LATIN AMERICA &		
CARIBBEAN	72.9	2009
Caribbean	61.6	1999
Antigua and		
Cuba	72.6	2006
Dominican Rep.	72.9	2007
Haiti	32.0	2005/6
Jamaica[a]	69.0	2002/3
Puerto Rico	84.1[c]	2002
Trinidad and		
Tobago[a]	42.5	2006

Central America	**68.2**	2009
Belize[a]	34.3	2006
El Salvador	72.5	2008
Guatemala	43.3	2002
Honduras	65.2	2005/6
Mexico	70.9	2006
Nicaragua	72.4	2006/7

OCEANIA	**59.8**	**2009**
Australia/		
New Zealand	**71.6**	2009
Australia	70.8	2001/2
New Zealand	74.9	1995
Melanesia/Micr		
onesia/		
Polynesia	**36.7**	2009
Cook Islands	43.2	1999
Guam		
Kiribati		
Marshall Islands		
Nauru	35.6	2007
Palau	32.8	2003
Papua New Guinea	35.7	2006
Samoa	28.7	2009
Solomon Islands	34.6	2006/7
Tuvalu	30.5	2007
Vanuatu	38.4	2007

EUROPE	**72.6**	**2009**
Eastern Europe	**74.9**	2009
Belarus	72.6	2005/6
Rep of Moldova	67.8	2005
Romania	70.3[c]	2004
Ukraine	66.7[c]	2007

Northern Europe	**80.1**	2009
Ireland	64.8[d,e]	2004/05
Norway	88.4	2005
United		
Kingdom	84.0[d,c,h]	2008/09

Southern Europe	**63.8**	2009
Albania	69.3	2008/9
Bosnia and		
Herzegovina	35.7	2005/6

			Portugal	86.8	2005/6
South America	**76.1**	2009	Serbia	41.2	2005
Bolivia	60.5	2008	Montenegro	39.4	2005/6
Brazil	80.3	2006	Spain	65.7	2006
Colombia	78.2	2004/5			
			Western		
Ecuador	72.7	2004	**Europe**	**71.9**	2009
Guyana	42.5[b]	2009	Belgium	74.6[e,e,f]	2004
Paraguay	79.4[e]	2008	France	76.6	2004/5
Peru	73.2[e]	2009	Netherlands	69.0	2008
Suriname	45.6	2006			
North America	78.1	2009			
Canada	74.0[d,e]	2002			
United States					
of America	78.6[e]	2006/8			

Table 3, Notes

[a]Adjusted.

[b]Preliminary data.

[c]Figures by method do not add up to the total.

[d]Figures by method do not add up to the total because some methods are used in combination.

[e]Data pertain to a non-standard age or marital status group/definition of unmet need for family planning.

[f] Data pertain to methods used during the last 12 months.

[g]Data pertain to nationals of the country

[h] Excluding Northern Ireland.

[l] Excluding Northern Province.

Source: United Nations Population Division: "World Contraceptive Use 2010" Wall Chart.

Although trends in prevalence vary from country to country, in the most successful programs the increase is about two percentage points a year (e.g., from 40 percent using a method to 42 percent). Increases above this level are not likely to be sustainable over the long term. That is why, in **Table 4**, such countries as Thailand, Cuba, Korea, and China fall into the bottom row and the left column. They already had large prevalence increases in the past and had reached high levels, and then slowed down.

In contrast, some countries with low starting levels, of 15 to 34 percent, have registered large gains. Examples include Oman and Afghanistan.

A third group of importance includes countries that started at very low levels and did not improve appreciably, shown in the upper left cell. Of the 77 countries contained in the table, 60 increased less than 1 percent a year (column 1), 13 increased between 1.0 and 1.9 percent a year (column 2), and only 4 increased by 2.0 percent or more a year.

Table 4: Annual Increase in Contraceptive Prevalence Around 1997-2009, by Prevalence at the Start of the Period

Prevalence Circa 1990	Annual Percentage-Point Increase in Contraceptive Prevalence		
	Less than 1.0	1.0-1.9	2.0 or More
Less than 15 percent	Mali 0.00 Sudan 0.10 Ethiopia 0.70 Mauritania 0.20 Guinea 0.30 Chad 0.60 Senegal 0.10 Burundi 0.70 Cote d'Ivoire 0.20 Niger 0.30 **Mean** **0.36**		
15-34 percent	Benin 0.10 Cameroon 0.40 Gambia 0.10 Ghana 0.10 Burkina Faso 0.60 Laos 0.60 Haiti 0.40 Yemen 0.60 Uganda 0.2 **Mean** **0.34**	Togo 1.00 Malawi 1.20 D.R. Congo 1.20 Central African Rep. 1.00 **Mean** **1.10**	Afghanistan 2.00 **Mean** **2.00**
35-49 percent	Trinidad and Tobago 0.50 Guyana 0.60 Iraq 0.70 Myanmar 0.60 Kenya 0.70 Guatemala 0.40 **Mean** **0.58**	Syria 1.40 Lesotho 1.80 Zambia 1.60 Nepal 1.62 Cambodia 1.80 **Mean** **1.64**	Rwanda 2.60 Madagascar 2.30 **Mean** **2.45**
50-64 percent	Azerbaijan 0.40 Lebanon 0.50 South Africa 0.30 Philippines 0.40 Indonesia 0.70 Bangladesh 0.20 Jordan 0.50 Zimbabwe 0.60 Egypt 0.50 Tunisia 0.60 Bolivia 0.80 Algeria 0.30 Morocco 0.30 Uzbekistan 0.30 **Mean** **0.46**	India 1.00 Kazakhstan 1.50 **Mean** **1.25**	Swaziland 2.50 **Mean** **2.50**
65+ percent	Iran (0.1) Mongolia 0.20 Mauritius 0.00 Thailand 0.50 Cuba 0.10 Rep. of Korea 0.10	Paraguay 1.50 El Salvador 1.10	

Puerto Rico	0.20			
China	0.20			
Sri Lanka	0.20			
Colombia	0.10			
Brazil	0.20			
Ecuador	0.60			
Peru	0.50			
Jamaica	0.20			
Turkey	0.70			
Dominican Republic	0.90			
Honduras	0.60			
Nicaragua	0.70			
Iran	0.10			
Mexico	0.20			
Vietnam	0.60			
Mean	**0.32**	**Mean**	**1.30**	

Source: United Nations Population Division: "World Contraceptive Use 2010" Wall Chart.

As shown in **Figure 1**, contraceptive prevalence and total fertility rates have a close linear relationship. Each increase of 10 points in prevalence is associated with a decline in the total fertility rate of 0.6 births. The variation around the regression line is due to differences in the pattern of contraceptive use and differences in the other proximate determinants.

Figure 1. The Relationship between the Total Fertility Rate and Contraceptive Prevalence, 194 Surveys from 80 Countries
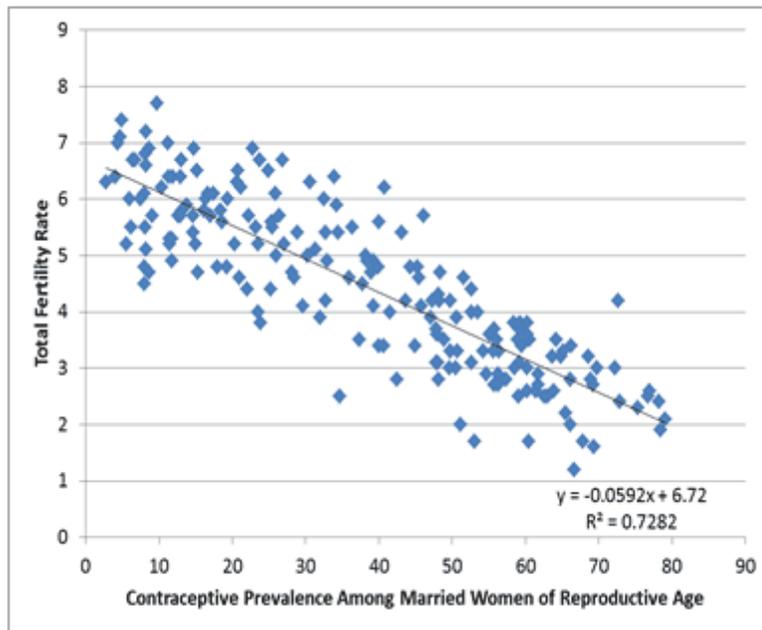
7.3.5.3.4 Reaching a goal for total fertility rate

Spectrum editor

1. **Prevalence.** Enter the contraceptive prevalence level in the base year.

2. **Total fertility rate.** Enter the actual TFR in the base year and the goal of the total fertility rate for all other years of the projection. In many cases it will be sufficient to enter a goal for the final year of the projection and interpolate from the first year.

The program goal may also be expressed as a future level of the total fertility rate for the region or nation. This approach is often used when the goal is to calculate the program requirements to achieve replacement-level fertility by some future year.

7.3.5.4 Post-abortion care

7.3.5.4.1 What is the post-abortion care component of FamPlan?

FamPlan includes a component for post-abortion care that can be used to estimate the effects of family planning programs on the number of abortions and the effects of changing numbers of abortions and treatment programs on maternal mortality.

The post-abortion care (PAC) component can be used to analyze how family planning programs and programs to treat abortion complications affect maternal deaths. It estimates the number of maternal deaths due to wanted births, unwanted births, and abortions, and shows how the allocation of expenditures can increase abortion treatments and reduce deaths.

7.3.5.4.2 Why make projections for post-abortion care (PAC)?

"PAC" is important because unsafe abortions are responsible for a substantial share of maternal deaths, and because treatment for abortion-related difficulties focuses upon a clearly identifiable clinical episode. The number of abortions is related to the number of unwanted pregnancies. Family planning programs and changes in the other proximate determinants of fertility can affect the number of unwanted pregnancies and, therefore, the number of abortions. The PAC component of FamPlan helps planners understand these interactions.

7.3.5.4.3 Post-abortion care editor inputs

Using the editor

In FamPlan, under "Configuration," you must choose the goal of reducing unmet need. Also under "Configuration," you must select the abortion option, "calculated from unwanted pregnancies." Then the following inputs are required.

1. The percent of unwanted pregnancies that terminate in abortion (an input in FamPlan under Proximate Determinants)
2. The percent of abortions that are legal
3. The percent of illegal abortions needing treatment
4. The percent of legal abortions needing treatment
5. The maternal mortality ratio (MMR)
6. The percent of all maternal deaths due to abortions
7. The relative risk of mortality for untreated vs. treated abortions
8. The annual expenditure on post-abortion care
9. The average cost per abortion complication treated
10. The average cost for family planning counseling/service per case.

For each input, here are suggestions for ways to obtain reasonable values. Illustrative numbers are shown in the **Figure 7** diagram. The number of pregnancies is calculated by FamPlan based on the total fertility rate. The number of unwanted pregnancies is calculated from two sources: pregnancies due to contraceptive method failure and pregnancies that occur to women with an unmet need for family planning.

Figure 7: Diagram for the Post-Abortion Care Model Illustrative Values for the First (Baseline) Year
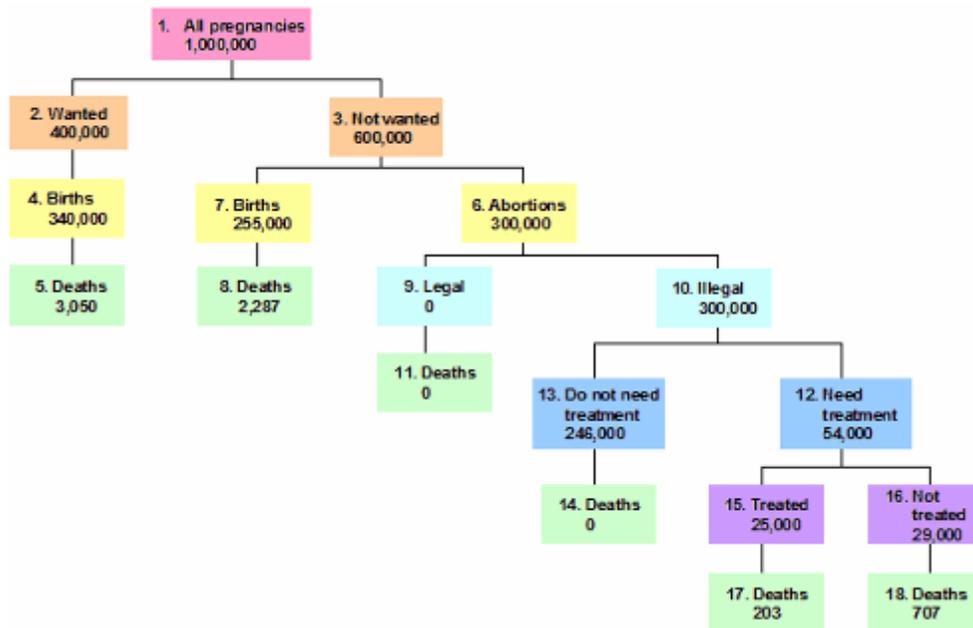
The proportion of unwanted pregnancies that are aborted is a direct input in FamPlan. This is assumed to be half in **Figure 7**, producing 300,000 abortions. The other 300,000 unwanted pregnancies are discounted by the 15 percent of miscarriages, producing 255,000 births. These births are subjected to the same mortality risk as before, resulting in 2,287 deaths.

In practice you must decide the proportion of unwanted pregnancies that are aborted from available data or local studies. A preliminary calculation can be made from the number of births, the numbers of abortions, an allowance for miscarriages as 15 percent of all pregnancies, and the proportion of births that are unwanted. The numerator is all abortions. The denominator, unwanted pregnancies, is the sum of all abortions, unwanted births, and perhaps half of all miscarriages. Alternative values can be tried and the final results examined to see whether small changes matter.

Table 28 provides estimates of unwanted births from DHS surveys.
Table 29 provides estimates for numbers of all abortions, and unsafe abortions
Table 30 provides estimates for numbers of maternal deaths and births.

Table 28: Percentage of Births Not Wanted or Wanted Later in the Five Years Preceding the Survey (including current pregnancy)

	Time wanted birth (or current pregnancy)				
	Wanted Then	Wanted Later	Not Wanted	Missing	Total
Sub-Saharan Africa					
Benin 2006	82.0	13.7	3.5	0.7	100.0
Benin 2001	77.2	17.5	4.9	0.4	100.0
Burkina Faso 2010	91.5	6.6	1.6	0.3	100.0
Burkina Faso 2003	76.9	20.0	2.9	0.3	100.0
Cameroon 2011	75.3	17.5	6.2	1.0	100.0
Cameroon 2004	77.3	17.4	4.7	0.7	100.0
CAR 1994/95	75.7	16.0	7.0	1.3	100.0
Chad 2004	82.9	15.8	1.0	0.3	100.0
Comoros 1996	42.5	41.3	14.4	1.8	100.0
Cote d'Ivoire 1994	65.0	20.1	7.9	0.8	93.8
Cote d'Ivoire 1998/99	70.7	23.8	4.9	0.6	100.0
Eritrea 2002	73.8	19.5	5.9	0.8	100.0
Ethiopia 2011	71.5	19.5	8.8	0.2	100.0
Gabon 2000	54.9	37.6	6.8	0.7	100.0
Ghana 2008	62.3	23.1	14.2	0.4	100.0
Ghana 2003	59.4	24.1	15.7	0.7	100.0
Guinea 2005	85.5	10.4	3.5	0.6	100.0
Kenya 2008/09	57.2	25.5	17.1	0.2	100.0
Kenya 2003	55.2	24.9	19.6	0.3	100.0
Madagascar 2008/09	86.9	7.7	4.6	0.8	100.0
Madagascar 2003/04	83.3	9.6	6.3	0.8	100.0
Malawi 2010	55.4	18.8	25.5	0.3	100.0
Malawi 2004	59.5	20.5	19.9	0.1	100.0
Mali 2006	83.3	12.9	3.1	0.8	100.0
Mali 2001	79.1	16.6	3.2	1.0	100.0
Mauritania 2000/01	71.2	22.1	6.3	0.4	100.0
Mozambique 2003	79.7	16.0	3.7	0.5	100.0
Namibia 2000	54.0	21.4	12.3	1.3	100.0
Niger 2006	89.1	9.2	0.4	1.3	100.0
Niger 1998	86.7	11.0	1.0	1.3	100.0
Nigeria 2008	87.3	6.5	4.2	2.1	100.0
Nigeria 2003	84.7	9.5	5.0	0.8	100.0
Rwanda 2010	62.3	25.1	12.5	0.2	100.0
Rwanda 2007/08	51.6	12.5	21.9	14.0	100.0
Senegal 2010/11	75.5	20.4	4.1	0.0	100.0
Senegal 2005	70.7	24.2	4.4	0.8	100.0
South Africa 1998	45.7	35.5	17.3	1.4	100.0

Tanzania 2010	73.6	22.1	3.7	0.6	100.0
Tanzania 2004/5	76.4	18.3	5.2	0.1	100.0
Tanzania 1999	77.5	11.4	11.0	0.2	100.0
Togo 1998	57.1	33.3	8.1	1.4	100.0
Uganda 2006	53.9	32.5	13.3	0.2	100.0
Uganda 2000/01	60.3	24.8	14.6	0.3	100.0
Zambia 2007	65.7	26.0	7.4	0.9	100.0
Zambia 2001/02	59.4	21.4	18.9	0.3	100.0
Zambia 1996	62.7	29.2	6.5	1.6	100.0
Zimbabwe 2010/11	67.9	25.1	7.0	0.1	100.0
Zimbabwe 2005/06	66.5	20.3	12.9	0.3	100.0
North Africa/West Asia/Europe					
Armenia 2010	91.3	7.0	1.4	0.4	100.0
Egypt 2008	85.7	5.1	8.7	0.5	100.0
Egypt 2005	80.1	7.3	11.7	0.9	100.0
Egypt 2000	81.5	5.0	13.4	0.1	100.0
Jordan 2009	73.5	15.6	10.8	0.0	100.0
Jordan 2007	73.9	14.7	11.3	0.0	100.0
Morocco 2003/04	69.6	15.1	14.8	0.5	100.0
Turkey 1993	67.5	12.0	20.4	0.1	100.0
Turkey 1998	69.2	11.2	18.8	0.7	100.0
Yemen 1997	54.6	23.0	21.8	0.6	100.0
Central Asia					
Kazakhstan 1999	82.4	8.3	8.9	0.3	100.0
Kazakhstan 1995	83.9	8.4	7.7	-	100.0
Kyrgyz Republic 1997	86.4	7.6	5.4	0.6	100.0
Turkmenistan 2000	94.3	2.2	1.2	2.2	100.0
Uzbekistan 1996	94.7	2.4	1.9	0.9	100.0
South & Southeast Asia					
Bangladesh 2007	71.0	14.8	14.1	0.1	100.0
Bangladesh 2004	70.4	15.7	13.8	0.1	100.0
Bangladesh 1999/2000	66.9	19.3	13.5	0.3	100.0
Cambodia 2010	84.3	6.6	8.8	0.3	100.0
India 2005/6	79.0	10.0	10.8	0.3	100.0
India 1998/99	78.4	11.9	9.4	0.3	100.0
Indonesia 2007	79.6	12.3	7.4	0.7	100.0
Indonesia 2002/03	82.4	9.6	7.2	0.9	100.0
Indonesia 1997	83.0	8.7	8.3	0.0	100.0
Nepal 2011	74.4	12.4	13.3	-	100.0
Nepal 2006	69.2	14.4	16.4	0.1	100.0
Pakistan 2006/7	74.9	13.2	10.9	1.1	100.0
Philippines 2008	63.0	20.2	16.3	0.5	100.0
Philippines 2003	54.9	24.0	20.3	0.8	100.0
Vietnam 2002	75.9	13.6	9.3	1.1	100.0

Latin America & Caribbean					
Bolivia 2008	38.6	25.6	35.6	0.1	100.0
Bolivia 2003	37.8	22.5	39.4	0.3	100.0
Brazil 1996	50.6	26.1	22.3	1.0	100.0
Brazil 1991 (1)	54.7	20.8	24.3	0.2	100.0
Colombia 2010	47.8	29.1	23.1	-	100.0
Colombia 2005	46.0	27.4	26.6	-	100.0
Colombia 2000	47.6	29.2	23.1	0.1	100.0
Dominican Republic 2007	54.6	30.2	14.1	1.1	100.0
Dominican Republic 2002	55.5	30.0	13.2	1.2	100.0
Dominican Republic 1999	53.4	32.5	13.7	0.5	100.0
Guatemala 2008/09	63.8	18.8	17.2	0.2	100.0
Guatemala 1998/99	69.7	18.0	11.8	0.5	100.0
Haiti 2005/06	52.4	21.0	26.4	0.2	100.0
Haiti 2000	43.9	26.0	29.8	0.2	100.0
Nicaragua 2006/07	64.0	22.5	13.3	0.2	100.0
Paraguay 2008	69.1	23.6	7.3	0.1	100.0
Peru 2007/08	43.3	31.8	24.9	0.0	100.0
Peru 2004/6	42.8	30.3	26.8	0.0	100.0
Peru 2000	43.8	25.3	30.7	0.2	100.0

1) Northeast region
Source: ICF International, 2012. MEASURE DHS+ STATcompiler. http://www.measuredhs.com, January 18, 2013.

Table 29: Estimates of abortion numbers, rates, ratios, and mortality (annual averages for 1995-2000)

	Total Abortions (000)	Legal Abortions (000)	Illegal (unsafe) abortions (000)	Rate: Unsafe abortions per 1000 women aged 15-49	Ratio: Unsafe abortions per 100 births	No. of deaths due to unsafe abortions	Deaths due to unsafe abortions per 100,000 births	Percent of all maternal deaths due to unsafe abortions
WORLD TOTAL	45.5	25.6	19.9	13	15	78,000	57	13
DEVELOPED REGIONS	10	9.1	0.9	3	7	500	4	13
Excluding Eastern Europe	3.8	3.7	0.1					
DEVELOPING REGIONS	35.5	16.5	19.0	16	16	77,500	63	13
Excluding China	24.9	5.9	19.0					
AFRICA	5.0	b	5.0	27	16	34,000	110	13
Eastern Africa	1.9	b	1.9	36	19	16,000	153	14
Middle Africa	0.6	b	0.6	28	14	4,000	98	10
Northern Africa	0.6	b	0.6	15	13	1,200	24	7
Southern Africa	0.2	b	0.2	16	13	800	49	19
Western Africa	1.6	b	1.6	31	16	12,000	121	12
ASIA[a]	26.8	16.9	9.9	11	13	38,500	48	12
Eastern Asia	12.5	12.5	b	**	**	**	**	**
South-central Asia	8.4	1.9	6.5	19	17	29,000	72	13
South-eastern Asia	4.7	1.9	2.8	21	23	8,100	66	15
Western Asia	1.2	0.7	0.5	12	11	1,100	20	6
EUROPE	7.7	6.8	0.9	5	12	500	6	17
Eastern Europe	6.2	5.4	0.8	10	25	500	15	24
Northern Europe	0.4	0.3	<0.03	1	2	<20	0.2	2
Southern Europe	0.8	0.7	<0.09	2	6	<20	1	10
Western Europe	0.4	0.4	b	**	**	**	**	**
LATIN AMERICA	4.2	0.2	4.0	30	36	5,000	41	21
Caribbean	0.4	0.2	0.2	17	21	600	71	18
Central America	0.9	b	0.9	26	26	700	20	14
South America	3.0	b	3.0	34	42	3,500	47	24
NORTHERN AMERICA	1.5	1.5	b	**	**	**	**	**
OCEANIA[a]	0.1	0.1	b	15	12	150	51	8

Figures may not add to totals due to rounding.

[a] Japan, Australia and New Zealand have been excluded from the regional estimates, but are included in the total for developed countries.

[b] Fewer than 50,000.

** For regions where the incidence is negligible, no estimates are shown.

Sources: *Unsafe Abortion: Global and Regional Estimates of Incidence of and Mortality Due to Unsafe Abortion with a Listing of Available Country Data* ." Third Edition. Geneva: WHO Division of Reproductive Health (Technical Support) 1998. Also: S.K. Henshaw, S. Singh, and T. Haas. "The Incidence of Abortion Worldwide." *International Family Planning Perspectives* , vol. 25, Supplement, Table 1, Jan. 1999.

Table 30: Estimates for 2000 of Maternal Deaths, MMRs, and Implied Number of Births

	No. of maternal deaths	MMR	Implied no. of births
ASIA/PACIFIC			
Afghanistan	20,000	1,900	1,052,632
Bangladesh	16,000	380	4,210,526
Bhutan	310	420	73,810
Brunei Darussalam	2	37	5,405
Cambodia	2,100	450	466,667
China	11,000	56	19,642,857
Fiji	15	75	20,000
India	136,000	540	25,185,185
Indonesia	10,000	230	4,347,826
Iran	1,200	76	1,578,947
Korea, DR	260	67	388,060
Korea, Rep.	120	20	600,000
Laos	1,300	650	200,000
Malaysia	220	41	536,585
Maldives	10	110	9,091
Mongolia	65	110	59,091
Myanmar	4,300	360	1,194,444
Nepal	6,000	740	810,811
Pakistan	26,000	500	5,200,000
Papua New Guinea	470	300	156,667
Philippines	4,100	200	2,050,000
Singapore	15	30	50,000
Solomon Islands	25	130	19,231
Sri Lanka	300	92	326,087
Thailand	520	44	1,181,818
Timor-Leste	140	660	21,212
Vanuatu***	10	130	7,692
Vietnam	2,000	130	1,538,462
LATIN AMERICA			
Argentina	590	82	719,512
Bahamas	4	60	6,667
Barbados	3	95	3,158
Belize	10	140	7,143
Bolivia	1,100	420	261,905
Brazil	8,700	260	3,346,154
Chile	90	31	290,323
Colombia	1,300	130	1,000,000
Costa Rica	40	43	93,023
Cuba	45	33	136,364
Dominican Republic	300	150	200,000
Ecuador	400	130	307,692
El Salvador	250	150	166,667
Guatemala	970	240	404,167
Guyana	30	170	17,647
Haiti	1,700	680	250,000
Honduras	220	110	200,000
Jamaica	45	87	51,724
Mexico	1,900	83	2,289,157
Netherlands Antilles***	1	20	5,000

Nicaragua	400	230	173,913
Panama	100	160	62,500
Paraguay	280	170	164,706
Peru	2,500	410	609,756
Puerto Rico	15	25	60,000
Suriname	10	110	9,091
Trinidad and Tobago	30	160	18,750
Uruguay	15	27	55,556
Venezuela	550	96	572,917
MIDDLE EAST/N. AFRICA			
Algeria	1,000	140	714,286
Bahrain	3	28	10,714
Cyprus	5	47	10,638
Egypt	1,400	84	1,666,667
Iraq	2,000	250	800,000
Jordan	70	41	170,732
Kuwait	2	5	40,000
Lebanon	100	150	66,667
Libya	140	97	144,330
Malta***	1	21	4,762
Morocco	1,700	220	772,727
Occupied Palestinian Terr.	130	100	130,000
Oman	80	87	91,954
Qatar	1	7	14,286
Saudi Arabia	160	23	695,652
Sudan	6,400	590	1,084,746
Syria	780	160	487,500
Tunisia	210	120	175,000
Turkey	1,000	70	1,428,571
United Arab Emirates	20	54	37,037
Yemen	5,300	570	929,825
SUB-SAHARA AFRICA			
Angola	11,000	1,700	647,059
Benin	2,200	850	258,824
Botswana	50	100	50,000
Burkina Faso	5,400	1,000	540,000
Burundi	2,800	1,000	280,000
Cameroon	4,000	730	547,945
Cape Verde	20	150	13,333
Central African Republic	1,600	1,100	145,455
Chad	4,200	1,100	381,818
Comoros	130	480	27,083
Congo	690	510	135,294
Congo, Dem. Rep.	24,000	990	2,424,242
Cote d'Ivoire	3,900	690	565,217
Djibouti	180	730	24,658
Equatorial Guinea	180	880	20,455
Eritrea	930	630	147,619
Ethiopia	24,000	850	2,823,529
Gabon	200	420	47,619
Gambia	270	540	50,000
Ghana	3,500	540	648,148

Guinea	2,700	740	364,865
Guinea-Bissau	590	1,100	53,636
Kenya	11,000	1,000	1,100,000
Lesotho	380	550	69,091
Liberia	1,200	760	157,895
Madagascar	3,800	550	690,909
Malawi	9,300	1,800	516,667
Mali	6,800	1,200	566,667
Mauritania	1,200	1,000	120,000
Mauritius	5	24	20,833
Mozambique	7,900	1,000	790,000
Namibia	190	300	63,333
Niger	9,700	1,600	606,250
Nigeria	37,000	800	4,625,000
Reunion	5	41	12,195
Rwanda	4,200	1,400	300,000
Senegal	2,500	690	362,319
Somalia	5,100	1,100	463,636
Sierra Leone	4,500	2,000	225,000
South Africa	2,600	230	1,130,435
Swaziland	120	370	32,432
Tanzania	21,000	1,500	1,400,000
Togo	1,000	570	175,439
Uganda	10,000	880	1,136,364
Western Sahara***	70	850	8,235
Zambia	3,300	750	440,000
Zimbabwe	5,000	1,100	454,545
CENTRAL ASIAN REP.			
Kazakhstan	560	210	266,667
Kyrgyzstan	110	110	100,000
Tajikistan	160	100	160,000
Turkmenistan	40	31	129,032
Uzbekistan	130	24	541,667
CAUCASUS			
Armenia	20	55	36,364
Azerbaijan	100	94	106,383
Georgia	20	32	62,500
EASTERN EUROPE			
Albania	35	55	63,636
Belarus	30	35	85,714
Bosnia-Herzegovina	10	31	32,258
Bulgaria	20	32	62,500
Croatia	4	8	50,000
Czech Republic	10	9	111,111
Estonia	5	63	7,937
Hungary	15	16	93,750
Latvia	10	42	23,810
Lithuania	4	13	30,769
Macedonia, former Yugo. Rep.	5	23	21,739
Moldova	20	36	55,556
Romania	110	49	224,490
Russian Federation	830	67	1,238,806
Serbia and Montenegro	15	11	136,364
Slovakia	2	3	66,667
Slovenia	3	17	17,647
Ukraine	140	35	400,000

***For countries with less than 300,000 population or no data, estimates from the 1995 report were used.

Sources: Carla Abou-Zahr and Tessa Wardlaw, "Maternal Mortality in 2000: Estimates Developed by WHO, UNICEF, and UNFPA" http://www.childinfo.org/files/maternal_mortality_in_2000.pdf accessed March 17, 2004.

For 1995 estimates see Kenneth Hill, Carla AbouZahr, and Tessa Wardlaw. "Estimates of Maternal Mortality for 1995" *Bulletin of the World Health Organization*, 2001, 79(3).

1. The percentage of all abortions that are legal, assumed to be zero in **Figure 7**. This is highly dependent on the country situation; it can vary from nearly zero to nearly one hundred. Also, the laws may say that only some abortions are legal depending upon the specific justification. The compilation in **Table 29** provides estimates, which may be applicable to your country, or you may have more recent information that you prefer to use. In **Figure 7** essentially no abortions are legal, so zero is used as the input.

   The PAC software assumes that legal abortions are safe, and so for simplicity they are assigned a zero mortality rate. If abortions are legal in your country, and you wish to allow for a mortality risk for them, you can do so by assigning all abortions to the illegal category and simply regard that as the legal category. (Then enter zero as the input for "legal" abortions.) You then proceed to follow all the instructions above in the same way, to obtain the numbers of deaths that result under "Outputs" below.

   However in countries where most abortions are illegal it is hardly necessary to allow for deaths from legal abortions. The legal abortions will be very few and generally safe, and so the numbers of deaths from them will be quite small in comparison to deaths from the many illegal abortions.

2. The percentage of illegal abortions needing treatment, assumed to be 18 percent in **Figure 7**, yielding 54,000. Among illegal abortions, some will not require any treatment whereas others will need attention. This varies by country: in some places many or most illegal abortions are performed in safe settings and rather few have side effects requiring treatment. A rough indicator for the percentage of abortions needing treatment is in **Table 31**, which has estimates of the percent of the population with ready access to safe abortion. When this percentage is very low, more abortions will be unsafe and will require special post-abortion care. However a high figure does not guarantee that few post-treatments will be needed, since actual use of a safe service normally falls well below the percent making actual use of it. In many countries a substantial percentage of abortions are quite unsafe, and many require subsequent clinical treatment. After you input the percentage needing treatment, the model calculates the percentage not needing treatment (246,000) all of which are presumed to be relatively safe. The 54,000 needing treatment are divided into those receiving it (25,000) and those not (29,000). As explained below, the total expenditure divided by the total cost per case treated produces the number that can be treated. Then separate mortality risks are applied to those treated (lower risk) and those not (higher risk). The **Figure 7** result is 203 deaths and 707 deaths for the two groups respectively.

Table 31: Estimates of the Percentage of the Population Having Ready and Easy Access to Safe Abortion Services, 1999

ASIA			MIDDLE EAST/ NORTH AFRICA			CENTRAL ASIAN REP.	
Bangladesh	66		Algeria	62		Kazakhstan	100
Myanmar	39		Egypt	5		Kyrgyzstan	91
China	100		Iran	64		Uzbekistan	100
Hong Kong	100		Jordan	57		Tajikistan	83
India	42		Lebanon	55		Turkmenistan	100
Indonesia	25		Morocco	34			
Cambodia	17		Oman	100			
Korea, Rep	100		Syria	59			
Laos	18		Tunisia	53			
Malaysia	65		Turkey	89			
Mongolia	51		Yemen	80			
Nepal	14						
Pakistan	16		SUB-SAHARAN AFRICA				
Philippines	25		Benin	25			
Sri Lanka	58		Burkina Faso	12			
Taiwan	100		Cameroon	15			
Thailand	44		Central African Rep	23			
Vietnam	96		Chad	3			
			Congo	43			
LATIN AMERICA			Cote d'Ivoire	52			
Argentina	37		Ethiopia	11			
Bolivia	63		Gabon	35			
Brazil	100		Ghana	39			
Chile	23		Guinea	34			
Colombia	19		Kenya	50			
Costa Rica	13		Lesotho	0			
Dominican Republic	0		Madagascar	63			
Ecuador	2		Malawi	4			
El Salvador	8		Mali	0			
Guatemala	1		Mauritania	0			
Guyana	23		Mauritius	35			
Haiti	60		Mozambique	3			
Honduras	36		Namibia	65			
Jamaica	59		Niger	15			
Mexico	58		Nigeria	18			
Nicaragua	6		Rwanda	2			
Panama	16		Senegal	0			
Paraguay	100		South Africa	58			
Peru	96		Sudan	0			
Puerto Rico	94		Tanzania	47			
Trinidad & Tobago	30		Togo	21			
Uruguay	21		Uganda	14			
Venezuela	59		Zambia	28			
			Zimbabwe	20			

3. The maternal mortality ratio (MMR) is assumed here to be 1050 in the baseline year (stated per 100,000 births even though some deaths come from abortions, since births are easier to count as the denominator).   Sources for the MMR include certain DHS and other surveys. Also, estimates for most countries for 2000 are given in **Table 30**.

All maternal deaths can be divided into those related to delivery and those related to abortions. Thus abortion deaths are a percentage of all maternal deaths, so the MMR can be divided between the portion related to deliveries and that related to abortions. The former may be termed the "Birth-MMR" (897 used in **Figure 7**) and the later "the Abortion-MMR" (153 used in **Figure 7**). The two are additive and sum to the MMR of 1050. (They use the same denominator of all births, but divide the numerator into the delivery-related deaths and the abortion-related deaths.)   For the latter, values for around 1995-2000 are available by region from WHO; these appear in **Table 29** (next to last column)

and can be converted to the proportion of all maternal deaths due to abortion (last column). A value in this table may appear applicable to your country, or you may have a local estimate. Note that a local estimate may pertain to abortion deaths on the denominator of abortions, not births as in the Abortion-MMR; if so it would need to be adapted.

The MMR you enter, along with the input for the percent of deaths due to abortions, fix the baseline mortality risks. Another input below, the relative risk between treated and untreated abortions, is also important. All these together determine the base-year mortality risks for births, treated abortions, and untreated abortions. In later years the MMR varies, being dependent upon the number of abortions that are treated (as well as the changing number of births and unwanted pregnancies).

4. The percent of maternal deaths due to abortions: assumed to be 14.6 percent in the base year. This may come from local data based upon available surveys, hospital statistics, or other sources of death statistics (see **Table 29**, last column). If the figure is subject to considerable guesswork it can be varied in alternative runs to see if the final conclusions are very sensitive to this input. After the base year the percent of all deaths due to abortions varies, depending upon the number of abortions that are treated.

5. The relative risk of mortality for untreated versus treated abortions, assumed to be 3 to 1 in **Figure 7**. Abortions needing treatment are split between those that actually receive treatment and those that do not, and the risk of death will be quite different between them. If only the most desperate cases are seen clinically their death rate may be above that of the untreated group, but the reverse situation may prevail, in which serious cases unable to reach treatment in time die at high rates. In any case, to use the software it is best to assume a higher risk among untreated cases, so that program actions that treat more cases will lower the overall death rate rather than raise it. Therefore the relative risk should be set at a value above 1, to make the risk of untreated cases higher than that of treated cases.

Table 30 provides country estimates for maternal deaths, maternal mortality ratios, and by division, the implied number of births. It must be emphasized that the MMR estimates are subject to large errors; the original source cited gives a range of uncertainty for each one, with a lower and upper estimate. Also, the number of births, as of 2000, may differ in other sources. The United Nations provides estimates of births as averages for five-year periods or you may have recent country figures.

Figure 7 assumes that the untreated group is made up of the more serious cases, so their death rate is three times the rate for the treated group. This ratio is combined with the baseline risk of death among all illegal abortions needing treatment to produce the actual risk assigned to each group, which turns out to be 0.81 percent for treated cases and 2.44 percent for untreated cases in a 1 to 3 ratio). As noted above, these baseline risks are then kept fixed over time, so that program interventions to treat more abortions move more cases to the lower risk group and so reduce total deaths.

6. The annual expenditure on post-abortion care is assumed to be $US 1,000,000 for calculating treated abortions in **Figure 7**. This would normally come from the national health budget and must be estimated from the available information, both for the baseline amount and the projected amounts. An alternative is that it might come from local studies in specific geographic areas that are reasonably representative and give results that can be enlarged proportionately to the whole population. Note that a precise figure is not necessary since the model is generally used to explore *changes* from a base plan to an alternative. The changes in outcomes may be about the same whether one starts from the precise annual expenditure or something close to it. All this allows for "what-if" explorations of how much maternal deaths might be reduced if funding could be increased, in combination with changes in various program inputs either in FamPlan or in the Post-Abortion Care module.

7. The average cost per post-abortion case that is treated is the sum of two separate inputs: (a) the average cost of treating the complications of the abortion itself, and (b) the average cost of providing family planning counseling and service. Each of the two costs must be estimated and entered separately. For simplicity, each input is a single figure: the first one is to summarize the various treatment costs such as supplies and personnel time, and the second one is for the various family planning costs that reflect the percent of treated cases who are offered family planning, the percent who adopt a method, and the costs of the particular methods chosen (pill, IUD, sterilization, etc.). Some local data may be available on the proportions who adopt each method, or no method, at the time of the post-abortion treatment. The sum of the two costs is assumed to be $40 in **Figure 7**, and that is divided into the total expenditure in item 9 to determine how many abortions can fall into the treated category. ($1,000,000/$40 = 25,000 cases treated.)

For your country you may be able to access Ministry of Health records or use local studies that seem fairly representative. An alternative is to conduct a fresh study to gather current data. Trying alternative values for this input will show how sensitive to it the final conclusions are.

Note also that if you are exploring all family planning costs for the entire country in FamPlan, there will be a small overlap between those and the family planning costs in the PAC module. This will normally not be a serious problem since the latter will be very small in comparison to the costs in the whole country. Further, this can be ignored if you are using the PAC module as a stand-alone exercise, to explore alternative assumptions for PAC activities.

That completes the list of inputs. In **Figure 7** the boxes give the numbers of deaths; these are generated from the death rate applied to the group at risk just above each box. The six boxes for deaths sum to all maternal deaths in the entire population. After the first year the numbers of deaths can change depending upon changes in the program inputs.

Percentage of abortions that are legal

The percentage of abortions that are legal is highly dependent on the country situation; it can vary from nearly zero to nearly one hundred. Also, the laws may say that only some abortions are legal depending upon the specific justification. FamPlan assumes that legal abortions are safe, and so for simplicity they are assigned a zero mortality rate. If abortions are legal in your country, and you wish to allow for a mortality risk for them, you can do so by assigning all abortions to the illegal category and simply regard that as the legal category. (Then enter zero as the input for "legal" abortions.) However in countries where most abortions are illegal it is hardly necessary to allow for deaths from legal abortions. The legal abortions will be very few and generally safe, and so the numbers of deaths from them will be quite small in comparison to deaths from the many illegal abortions.

Percentage of illegal abortions that need treatment

Among illegal abortions, some will not require any treatment whereas others will need attention. This varies by country: in some places many or most illegal abortions are performed in safe settings and rather few have side effects requiring treatment. When the percentage of the population with ready access to safe abortion is very low, more abortions will be unsafe and will require special post-abortion care. However a high figure does not guarantee that few post-treatments will be needed, since actual use of a safe service normally falls well below the percent making actual use of it. In many countries a substantial percentage of abortions are quite unsafe, and many require subsequent clinical treatment.

Maternal mortality ratio (MMR)

All maternal deaths can be divided into those related to delivery and those related to abortions. Thus abortion deaths are a percentage of all maternal deaths, so the Maternal mortality ratio (MMR) can be divided between the portion related to deliveries and that related to abortions. The former may be termed the "Birth-MMR" and the later "the Abortion-MMR". The two are additive and sum to the MMR. (They use the same denominator of all births, but divide the numerator into the delivery-related deaths and the abortion-related deaths.)

The MMR you enter, along with the input for the percent of deaths due to abortions, fix the baseline mortality risks. Another input, the relative risk between treated and untreated abortions, is also important. All these together determine the base-year mortality risks for births, treated abortions, and untreated abortions. In later years the MMR varies, being dependent upon the number of abortions that are treated (as well as the changing number of births and unwanted pregnancies).

Percent of maternal deaths due to abortions

The percent of maternal deaths due to abortions may come from local data based upon available surveys, hospital statistics, or other sources of death statistics. If the figure is subject to considerable guesswork it can be varied in alternative runs to see if the final conclusions are very sensitive to this input. After the base year the percent of all deaths due to abortions varies, depending upon the number of abortions that are treated.

Relative risk of mortality for untreated versus treated abortions

Abortions needing treatment are split between those that actually receive treatment and those that do not, and the risk of death will be quite different between them. If only the most desperate cases are seen clinically their death rate may be above that of the untreated group, but the reverse situation may prevail, in which serious cases unable to reach treatment in time die at high rates. In any case, to use FamPlan it is best to assume a higher risk among untreated cases, so that program actions that treat more cases will lower the overall death rate rather than raise it. Therefore the relative risk should be set at a value above 1, to make the risk of untreated cases higher than that of treated cases.

Annual expenditure on post-abortion care

The annual expenditure on post-abortion care would normally come from the national health budget and must be estimated from the available information, both for the baseline amount and the projected amounts. An alternative is that it might come from local studies in specific geographic areas that are reasonably representative and give results that can be enlarged proportionately to the whole population. Note that a precise figure is not necessary since the model is generally used to explore *changes* from a base plan to an alternative. The changes in outcomes may be about the same whether one starts from the precise annual expenditure or something close to it. All this allows for "what-if" explorations of how much maternal deaths might be reduced if funding could be increased, in combination with changes in various program inputs in FamPlan.

Average cost per post-abortion case

The average cost per post-abortion case that is treated is the sum of two separate inputs: (a) the average cost of treating the complications of the abortion itself, and (b) the average cost of providing family planning counseling and service. Each of the two costs must be estimated and entered separately. For simplicity, each input is a single figure: the first one is to summarize the various treatment costs such as supplies and personnel time, and the second one is for the various family planning costs that reflect the percent of treated cases who are offered family planning, the percent who adopt a method, and the costs of the particular methods chosen (pill, IUD, sterilization, etc.). Some local data may be available on the proportions who adopt each method, or no method, at the time of the post-abortion treatment.

For your country you may be able to access Ministry of Health records or use local studies that seem fairly representative. An alternative is to conduct a fresh study to gather current data. Trying alternative values for this input will show how sensitive to it the final conclusions are.

7.3.5.4.4 Sample applications

Suppose you wish to use the PAC component of FamPlan for your country as of the year 2000. A key advantage of the model is that you can explore the effects of alternate scenarios, or intervention plans. You set up the baseline situation, for 2000, by assembling the information for all inputs. Here they pertain approximately to the situation in an East African country. Four variations are then introduced, each one illustrating a different way to strengthen post-abortion care.   The results are compared for what they imply for maternal deaths and other results. This illustrates the way in which managers can compare alternative actions and costs.

A convenient way to produce alternative sets of inputs like these is to save the baseline set under a new name for each set. That preserves all of the numerous specifications that you entered for DemProj and for FamPlan, including PAC, and you can then simply make the few modifications in each set that correspond to the alternative actions for it. Doing this repeatedly can create as many variations as you wish, and you can show up to four different plans on the screen simultaneously for convenient comparisons.

Here are the variations:

a*Baseline*   (the others below are exactly the same as the Baseline except for the change noted.)

b*Meet more unmet need.*   Unmet need in FamPlan in the baseline is 35 percent in 2000, and the percentage met increases linearly from 5 to 50 percent from 2001 to 2015. In the "B" run, the increase is to 80 percent in 2015 instead of 50 percent.

c*Improve the contraceptive method mix.*   In the baseline modern methods have only a constant 68.3 percent of the total; the "C" run improves this linearly to 90 percent by 2015.

d*Increase the national budget.*   In the baseline this is a flat $1 million a year; in the "D" run this increases to $1.75 million by 2015.

e*All of the above*   , from B, C, and D.

The results are contrasted in **Table 32** below.

Comments:

Scenario E, which does everything, has the fewest number of total deaths (only 13,370 deaths in 2015) and on the sum of deaths from treated and untreated abortions (all abortions are treated in E, partly because fewer abortions occur in E and also because the increased budget in D is incorporated). However E has the most deaths from wanted births (8,307) but the fewest from unwanted births (4,255), since it incorporates B and C, with their better method mix and reduced unmet need, which together shift the ratio of wanted to unwanted pregnancies.

For total deaths the various scenarios reduce the baseline figure by 17 percent, 8 percent and 4 percent for B, C, and D respectively, but by a full 30 percent for all three in E. For total abortion deaths (sum of columns 4 and 5) however, the reductions from the baseline are more impressive: 34 percent, 22 percent, and 21 percent, for B, C, and D respectively, but by 78 percent for E. The strong effect in E reflects the interactive advantage of having fewer abortions and treating them all.

(In all projections the relative risk is set at 3; 30 percent of abortions need treatment; and 20 percent of maternal deaths are due to abortions. The first year MMR is 1048.)

Table 32: Comparative Results from Five Scenarios Post-Abortion Care
(The 2000 Baseline figures apply to all scenarios.)

		No. abortions (all illegal)	Total Deaths	No. deaths from treated abortions	No. deaths from untreated abortions	No. deaths from wanted births	No. deaths from unwanted births
A. Baseline	2000	227,088	13,282	515	2,141	4,152	6,473
	2015	289,270	19,194	515	3,151	7,242	8,246
B. Unmet Need	2015	212,233	15,901	515	1,900	7,436	6,050
C. Method Mix	2015	239,533	17,602	515	2,343	7,915	6,828
D. Budget	2015	289,270	18,382	902	1,991	7,243	8,246
E. All above	2015	149,275	13,370	808	-	8,307	4,255
PERCENT REDUCTIONS FROM THE BASELINE 2015 FIGURES							
A. Baseline	2000	227,088	13,282	515	2,141	4,152	6,473
	2015	289,270	19,194	515	3,151	7,242	8,246
B. Unmet Need	2015	26.6	17.2	-	39.7	(2.7)	26.6
C. Method Mix	2015	17.2	8.3	-	25.6	(9.3)	17.2
D. Budget	2015	-	4.2	(75.1)	36.8	(0.0)	-
E. All above	2015	48.4	30.3	(56.9)	100.0	(14.7)	48.4

Table 33 gives the full detail of results for the five scenarios, and illustrates the time trends. (The software also provides for results by individual years.)

Table 33: Results from Five Scenarios for PAC Programs

	2000	2005	2010	2015
A. BASELINE SCENARIO				
Maternal Deaths: Total	13,282	15,132	17,068	19,154
From wanted births	4,152	5,043	6,002	7,242
From unwanted births	6,473	7,084	7,707	8,246
From treated illegal abortions	515	515	515	515
From untreated illegal abortions	2,141	2,489	2,844	3,151
Abortions	227,088	248,519	270,367	289,270
Illegal abortions: Total	227,088	248,519	270,367	289,270
Illegal abortions not needing treatment	158,962	173,964	189,257	202,489
Illegal abortions needing treatment	68,126	74,556	81,110	86,781
Illegal abortions treated	28,571	28,571	28,571	28,571
Illegal abortions untreated	39,555	45,984	52,539	58,209
MMR	1,048	1,046	1,044	1,037
Abortion deaths per 100,000 abortions	1,170	1,209	1,242	1,267
B. UNMET NEED SCENARIO				
Maternal Deaths: Total	13,282	14,374	15,255	15,901
From wanted births	4,152	5,047	6,060	7,436
From unwanted births	6,473	6,599	6,515	6,050
From treated illegal abortions	515	515	515	515
From untreated illegal abortions	2,141	2,212	2,165	1,900
Abortions	227,088	231,495	228,552	212,233
Illegal abortions: Total	227,088	231,495	228,552	212,233
Illegal abortions not needing treatment	158,962	162,047	159,986	148,563
Illegal abortions needing treatment	68,126	69,449	68,566	63,670
Illegal abortions treated	28,571	28,571	28,571	28,571
Illegal abortions untreated	39,555	40,877	39,994	35,098
MMR	1,048	1,035	1,017	989
Abortion deaths per 100,000 abortions	1,170	1,178	1,173	1,138
C. METHOD MIX SCENARIO				
Maternal Deaths: Total	13,282	14,765	16,264	17,602
From wanted births	4,152	5,138	6,302	7,915
From unwanted births	6,473	6,790	7,004	6,828
From treated illegal abortions	515	515	515	515
From untreated illegal abortions	2,141	2,321	2,443	2,343
Abortions	227,088	238,203	245,693	239,533
Illegal abortions: Total	227,088	238,203	245,693	239,533
Illegal abortions not needing treatment	158,962	166,742	171,985	167,673
Illegal abortions needing treatment	68,126	71,461	73,708	71,860
Illegal abortions treated	28,571	28,571	28,571	28,571
Illegal abortions untreated	39,555	42,890	45,136	43,288
MMR	1,048	1,038	1,025	1,001
Abortion deaths per 100,000 abortions	1,170	1,191	1,204	1,193

D. BUDGET SCENARIO

Maternal Deaths: Total	13,282	14,766	16,488	18,382
From wanted births	4,152	5,044	6,004	7,243
From unwanted births	6,473	7,015	7,664	8,246
From treated illegal abortions	515	644	773	902
From untreated illegal abortions	2,141	2,063	2,046	1,991
Abortions	227,088	246,087	268,874	289,270
Illegal abortions: Total	227,088	246,087	268,874	289,270
Illegal abortions not needing treatment	158,962	172,261	188,212	202,489
Illegal abortions needing treatment	68,126	73,826	80,662	86,781
Illegal abortions treated	28,571	35,714	42,857	50,000
Illegal abortions untreated	39,555	38,112	37,805	36,781
MMR	1,048	1,027	1,011	995
Abortion deaths per 100,000 abortions	1,170	1,100	1,049	1,000

E. EVERYTHING SCENARIO

Maternal Deaths: Total	13,282	13,760	13,898	13,370
From wanted births	4,152	4,938	6,129	8,307
From unwanted births	6,473	6,408	5,902	4,255
From treated illegal abortions	515	619	747	808
From untreated illegal abortions	2,141	1,795	1,120	-
Abortions	227,088	224,802	207,046	149,275
Illegal abortions: Total	227,088	224,802	207,046	149,275
Illegal abortions not needing treatment	158,962	157,361	144,932	104,492
Illegal abortions needing treatment	68,126	67,441	62,114	44,782
Illegal abortions treated	28,571	34,286	41,429	44,782
Illegal abortions untreated	39,555	33,155	20,685	-
MMR	1,048	1,017	969	892
Abortion deaths per 100,000 abortions	1,170	1,073	902	541

7.3.5.4.5 Methodology

The methodology of the PAC component is relatively straightforward. First the number of pregnancies is split between wanted and unwanted pregnancies. Then 85 percent of wanted pregnancies produce births; the other 15 percent is for miscarriages (not shown in **Figure 7**). Also, some unwanted pregnancies produce births, again after the 15 percent discount.   The births then produce maternal deaths according to the specialized MMR value that pertains to deaths associated just with births (not with abortions). It is important to note that the full MMR, for the entirety of all maternal deaths, is partitioned to those associated with births (the "Birth-MMR") and those associated with abortions (the "Abortion-MMR"). As noted elsewhere, the two are additive; they have the same denominator, and the two numerators can be summed to equal all maternal deaths.

To split unwanted pregnancies between abortions and births, the abortions are subtracted out first, then the remainder is multiplied by 85 percent to produce the number of births, thus allowing for miscarriages. The births are subjected to the "Birth-MMR" to produce deaths, as was done with the births from wanted pregnancies.

The abortions on the other hand are divided into legal and illegal abortions. Legal abortions are assumed for simplicity to be sufficiently safe to produce essentially no deaths.

Illegal abortions are then split between those that need treatment and those that do not. Those not needing treatment are again assumed for simplicity to be sufficiently safe to produce essentially no deaths.

Abortions needing treatment are of two types: those that actually receive treatment and those that do not. The model calculates the number receiving treatment by dividing the total expenditures by the total cost per treated case.

There are two mortality risks, one for abortions and one for births, which total to the MMR. An oddity in statistical practice is that the full MMR is calculated on the denominator of births, even though deaths come from both births and abortions. It is useful to separate deaths by the two causes, and one may be termed the "Abortion-MMR" and the other the "Birth-MMR," which add to the usual MMR.

The following equations follow **Figure 7**, taking each box in turn.

1. **Number of Pregnancies (Box 1) PREG**

    The number of pregnancies is a FamPlan output and is a complex result of numerous demographic and family planning inputs.

2. **Number of Wanted Pregnancies (Box 2) PREGW**

    This uses the input for the percent of all pregnancies that are unwanted.

    [2] PREGW = **PREG** X (1 − **%PREGNW**)

    where:

    PREGW = the number of pregnancies that are wanted

    PREG = the number of all pregnancies

    %PREGNW = the proportion of all pregnancies that are not wanted

    Example: 1,000,000 X (1 - .60) = 400,000 wanted pregnancies.

3. **Number of Unwanted Pregnancies (Box 3) PREGNW**

    [3] PREGNW = **PREG** X **%PREGNW**

    where:

    PREGNW = the number of pregnancies that are unwanted

    PREG = the number of all pregnancies

    %PREGNW = the proportion of all pregnancies that are not wanted

    Example: 1,000,000 X (.60) = 600,000 unwanted pregnancies.

4.   Number of Births from Wanted Pregnancies (Box 4) BW

[4] BW = PREGW X **0.85**

where

    BW   = the number of births from wanted pregnancies in Box 4

    PREGW   = the number of wanted pregnancies from above

    0.85   = the proportion of all pregnancies not ending in miscarriages

Example: BW = 400,000 X **0.85** = 340,000 births

5.   Number of Deaths Associated with Births from Wanted Pregnancies (Box 5) D1

[5] D1 = BW X Birth-MMR/100,000

where

    D1   = the number of deaths in Box 5

    BW   = the number of births from wanted pregnancies in Box 4

    Birth-MMR   = **MMR** − **Abortion-MMR** = 1050 - 153

Example: D1 = 340,000 * 897/100,000 =   3050 deaths

6.   Number of Abortions from Unwanted Pregnancies (Box 6) AB

    This variable is based upon the separation of all unwanted pregnancies into those ending in births and those ending in pregnancies.

[6] AB = PREGNW X **%PREGAB**

where:

    AB   = the number of unwanted pregnancies

    PREGNW   = the number of births from wanted pregnancies in Box 4

    %PREGAB = the proportion of unwanted pregnancies ending in abortions

Example: ANW = 600,000 X **0.50** = 300,000 abortions

7. Number of Births from Unwanted Pregnancies (Box 7) BNW

[7] BNW = (PREGNW − AB) X **0.85**

where:

    BNW   = the number of births from unwanted pregnancies

    PREGNW   = the number of unwanted pregnancies in Box 3

    AB   = the number of abortions from unwanted pregnancies

    0.85   = the proportion of pregnancies not ending in miscarriages

Example: BNW = (600,000 - 300,000) X **0.85** = 255,000

8. Number of Deaths from Births from Unwanted Pregnancies (Box 8) D2

[8] D2 = BNW X (**MMR** - **Abortion-MMR**)/100,000

where:

    D2   = the number of deaths associated with births from unwanted pregnancies

    BNW   = the number of births produced from unwanted pregnancies in Box 7

    MMR   = the maternal mortality ratio (all deaths over all births/100,000)

    Abortion-MMR   = the ratio of all abortion-deaths to all births/100,000)

Example: D2 = 255,000 X (**1050** − **153**)/100,000 = 2287

9. Number of Legal Abortions (Box 9) ABL

(In the **Figure 7** illustration all abortions are assumed to be illegal; none are legal. The proportion that are legal is an input and can vary from zero to 100%.)

[9] ABL = AB X **%ABL**

where

    ABL   = the number of legal abortions

    AB   = the number of all abortions in Box 6

    %ABL = the proportion of all abortions that are legal

Example: ABL = 300,000 X ZERO = 300,000

10. Number of Illegal Abortions (Box 10) ABNL

[10] ABNL = AB − ABL

where:

  ABNL = the number of illegal abortions

  AB = the number of all abortions in Box 6

  ABL = the number of legal abortions in Box 9

Example: ABNL = 300,000 - ZERO = 300,000

11. Number of Deaths from Legal Abortions (Box 11) D3

All legal abortions, for simplicity, are assumed to be sufficiently safe that no deaths result. D3 is assumed to be zero.

12. The Number of Illegal Abortions Needing Treatment (Box 12) ABNT

[11] ABNT = ABNL X **%ABNT**

where:

  ABNT = the number of illegal abortions needing treatment

  ABNL = the number of illegal abortions from Box 10

  %ABNT = the proportion of illegal abortions needing treatment

Example: ABNT = 300,000 X **0.18** = 54,000 illegal abortions needing treatment

13. The Number of Illegal Abortions Not Needing Treatment (Box 13) ABNNT

[12] ABNNT = ABNL − ABNT

where:

  ABNNT = the number of illegal abortions not needing treatment

  ABNL = the number of illegal abortions from Box 10 (FIX)

  ABNT = the number of illegal abortions that need treatment.

Example: ABNNT = 300,000 - 54,000 = 246,000 illegal abortions not needing treatment

14. Deaths from Illegal Abortions that Do Not Need Treatment (Box 14) D4

All such abortions, for simplicity, are assumed to be sufficiently safe that no deaths result.

D4 is assumed to be zero.

15. Number of Illegal Abortions Needing Treatment and Receive It (Box 15) ABNTT

The number of abortion cases that can be treated depends upon the total funding available and upon the total cost for treating each case. Note that if enough funding were available, the number of abortion cases that could be treated might exceed the total number needing it in Box 14. The software therefore includes a maximum limit, equal to the total number needing treatment.

[13] ABNTT = **TC/CPC**

where:

ABNTT   = the number of illegal abortions that both need treatment and receive it.

TC   = Total Expenditure

CPC   = Cost per case treated

Example: ABNTT = $1,000,000/$40 = 25,000 cases treated

16. Number of Illegal Abortions That Need Treatment But Do Not Receive It (Box 16) ABNTUT

[14] ABNTUT = ABNT − ABNTTT

where:

ABNTUT   = Number of illegal abortions needing treatment but are untreated

ABNT   = the number of illegal abortions needing treatment

ABNTT   = the number of illegal abortions that need treatment and do receive it.

Example: ABNTUT = 54,000 − 25,000 = 29,000 cases not treated

NOTE: Numbers of Deaths from Treated and Untreated Illegal Abortions (Boxes 17 and 18) D5 and D6.

The sum of deaths from treated and untreated abortions is made consistent with the overall risk of death from abortions in the baseline year.   As inputted in this example that ratio is 153 abortions per 100,000 *births*   , which is converted by the model to the ratio of 303 abortion deaths per 100,000 *abortions.*   However of all abortions, those in Box 13 involve no deaths, so a ratio is needed for all abortion deaths among cases needing treatment, in Box 12, and that is much higher, at 1683 (in

this example, it is the 303 ratio divided by 0.18, due to the input that 18 percent of all illegal abortions require treatment. Applying the 1683 ratio to the 54,000 cases in Box 12 produces 910 abortions, which must be allocated to Boxes 17 and 18.

Thus the death ratio, of 1683, governs the two ratios that apply to Boxes 15 and 16. In this illustration, the relative risk between the two boxes was inputted as 3 (i.e., the Box 16 risk is 3 times higher than the Box 15 risk). These levels, together with the number of cases in the two boxes, produce the numbers of deaths. The two equations follow.

17. Numbers of Deaths from Treated Illegal Abortions (Box17) D5

[15] D5 = ABNTT X DEATH RATIO

where:

ABNTT = Treated cases in Box 15

DEATH RATIO: depends upon the following:

0.463 of the 54,000 cases in Box 12 fall into Box 15 (= 25,000)

0.537 of the 54,000 cases in Box 12 fall into Box 16 (= 29,000)

3 is the relative risk as inputted

Example: 25,000 X (303/.18)/((.463 + (3 X .537))/100,000

Simplified: 25,000 X 1683/2.074/100,000 = 203 deaths

18. Numbers of Deaths From Untreated Illegal Abortions (Box18) D6

[16] D6 = ABNTUT X DEATH RATIO

where:

ABNTUT = untreated cases in Box 16

DEATH RATIO : depends upon the following:

0.463 of the 54,000 cases in Box 12 fall into Box 15

0.537 of the 54,000 cases in Box 12 fall into Box 16

3 is the relative risk as inputted

Example: 29,000 X (303/.18)/(.463/3 + .537)/100,000

Simplified: 29,000 X 1683/.691/100,000 = 707 deaths

Cost of Treating Illegal Abortions That Need It (TC)

The model lets you vary the expenditures on post-abortion care in order to explore the outcomes above. It starts therefore with a budget figure that represents the current annual expenditure on post-abortion care. This is an input, and it is allocated entirely to (a) treating unsafe abortions and (b) providing family planning counseling/services (Box 15). A total, for the sum of (a) and (b), is also inputted ($48 in this illustration). If the expenditure is large enough all abortions needing treatment receive it; otherwise only part of them will be treated.

TC   =   Inputted annual expenditure.

Where

TC = total cost

Example: TC = US $872,197

Cost of Treating Abortions per Death Averted (CDA)

If you compare two or more scenarios you can calculate the cost per additional death averted. Suppose that you compare a baseline projection with an alternative projection. Then the number of deaths averted is the difference between the base application and the intervention application. (All the inputs can be varied to represent the intervention plan, including the annual expenditure.) The model then calculates the numbers of deaths under both the base and the intervention, takes the difference (deaths averted), and compares that to the addition in the annual expenditure. Thus the calculation compares two increments: the deaths avoided and the expenditure increase.

[17] CDA = (Intervention expenditure – Base expenditure)/(Base deaths – Intervention deaths)

where

CDA = Cost per death averted

Base and intervention expenditures are inputted

Base and intervention deaths come from Boxes 17 and 18

Example: CDA = (1,500,000 - 872,197/(911 – 720) = $3313

7.3.5.5   Distribution of fertility related risk

Depending on the age of the mother, parity and interval between births, a birth may be more or less risky for the health of the child and the mother. The data in this table establish the baseline proportions of births that fall into each of the risk categories. FamPlan calculates reduction in proportions of risky births based on reductions in the total fertility rate. The user may click on "Advanced Parameters" for further information or to edit the relationship.

Default data comes from Demographic and Health Surveys or regional averages.

If activated, the Lives Saved Tool will translate reductions in the proportions of risky births into reductions in infant and child mortality.

Advanced parameters

This table presents the parameters underlying the relationship between TFR and proportions of risky births. Click on the highlighted hyper-link to download a spreadsheet that shows how the relationship works.

Example spreadsheet

7.3.5.6 LAM

What is the Lactational Amenorrhea Method (LAM)?

The Lactational Amenorrhea Method (LAM) is a modern, temporary family planning method that has been developed as a tool to help support both breastfeeding and family planning use. It is based on the natural infertility resulting from certain patterns of breastfeeding. "Lactational" means related to breastfeeding; "Amenorrhea" means not having menstrual bleeding; and "Method" means a technique for contraception.

LAM is defined by three mandatory criteria:

1. the woman's menstrual periods have not resumed, AND

2. the baby is fully or nearly fully breastfed, AND

3. the baby is less than six months old.

7.3.6   FamPlan results

7.3.6.1   Fertility and FP use

- **Total fertility rate** - The average number of children that would be born to a cohort of women who survive until age 50 and have births according to the prevailing age-specific birth rates.

- **Prevalence** - The percentage of married women of reproductive age using some form of contraception. Prevalence can be displayed for all methods, sources and needs (spacing or limiting) or for any combination of methods, sources and needs.

- **Percent unmet need**

- **Average effectiveness** - The average effectiveness of the methods selected, weighted by the number of users. This is the proportion of women using a method who will not become pregnant in that year.

- **Total fecundity** - The calculated total fecundity rate. Total fecundity is the average number of children who would be born to women if none of the proximate determinants were acting to reduce fertility from its biological maximum. In the model, fecundity is calculated for the base year only. It remains constant in all other years.

- **Users** - The number of women who are using some form of contraception. Users can be displayed for all methods and sources or for any combinations of methods and sources.

- **Acceptors** - The number of new users of a particular method in a particular year. A woman is classified as an acceptor if she starts using a method during the year and was not using that method at the start of the year. Previously she may have been using nothing or she may have been using a different method. Acceptors are calculated only for long-term methods where acceptance requires special service: IUD, sterilization, and implants. For short-term methods (pill, condom, injectable, vaginal, traditional) a new acceptor is difficult to identify and there is little difference in service requirements between an acceptor and a continuing user.

- **CYP**

- **Commodities** - The amount of supplies required for different methods to provide a specified level of family planning services. Commodities are expressed in terms of numbers of condoms, sterilization kits, injectable vials, IUDs, Norplant implants, pill cycles, and vaginal tablets. They can be displayed for any method and for all sources or any combination of sources.

- **Growth rates** - The increment in total number of contraceptive users from year to year. These are net figures, consisting of new users and the continuing users who remain after previous users either have discontinued or have "aged out."

- **Percent of births with any risk**

7.3.6.2   Women of reproductive age

- **Women of reproductive age** - The number of women of reproductive age, 15-49.

- **Married women of reproductive age** - The number of women of reproductive age who are married or in union.

7.3.6.3   Demographic events

- **Pregnancies** - The number of pregnancies occurring during a year. Pregnancies can be wanted, unwanted or mistimed. Unwanted pregnancies are those that occur due to method failure or those that occur to women who have an unmet need for limiting. Mistimed pregnancies are those that occur to women who have an unmet need for spacing. Wanted pregnancies are calculated as the total pregnancies minus those that are unwanted or mistimed. The selection of the goal for the family planning projections can have an impact on these indicators. Information about unmet need for spacing and limiting is available only for goal one (meeting unmet need). For all other goals, there will be no pregnancies that are designated as mistimed. Note that if unmet need is not taken into account, unwanted pregnancies may actually rise as prevalence increases, since more women will be exposed to the risk of contraceptive failure than when few women are using contraception.

- **Births** - The number of live births occurring during a year.

- **Abortions** - The number of induced abortions occurring during the year.

7.3.6.4   Fertility related risks

- **Age and birth order**

- **Birth intervals**

7.3.6.5   Mortality rates

- **Risk-adjusted IMR**

- **Risk-adjusted U5MR**

7.3.6.6   Costs and revenues

- **Gross cost** - The total public sector cost of providing family planning services. Gross cost can be displayed for all methods and sources or for any combinations of methods and sources.

- **Cost per user** - The public sector cost of providing family planning, per family planning user.

- **Revenue** - The total amount of revenue collected from fees for family planning services. Revenue can be displayed for all methods and sources or for any combinations of methods and sources.

- **Net cost** - The net public sector cost of family planning services. This figure is equal to gross cost minus revenue collected. Net cost can be displayed for all methods and sources or for any combinations of methods and sources.

7.3.6.7   Post-abortion care

The results from the post-abortion care component of FamPlan correspond to the items described in Post-abortion care editor inputs. These appear for all years included in your FamPlan projection. Alternative program scenarios can easily be constructed by simply saving the original file under new names and then varying some of the inputs in each one.

To examine the results of the projection, click on "Results" on the menu bar, then click on "Post-abortion care" and you will see the following options ready to be viewed:

- Maternal deaths: total
- Maternal deaths from wanted births
- Maternal deaths from unwanted births
- Maternal deaths from treated abortions
- Maternal deaths from untreated abortions
- Total deaths averted
- Total abortions
- Illegal abortions
- Abortions not needing treatment
- Abortions needing treatment
- Treated abortions
- Untreated abortions
- MMR
- Abortion deaths per 100,000 abortions
- Post-abortions care summary table

The result items are self-explanatory, and are discussed further in Sample applications and Methodology.

7.3.6.8   Summary

- **Summary of inputs** - Displays or prints a summary of all the input assumptions.

- **Summary of outputs** - Displays or prints a summary of all the output indicators.

7.3.7   Sample application

This section describes a typical application of FamPlan. It uses a data file that is a composite of data for several countries with low levels of prevalence.

We assume that a DHS is available for the sample country. We also assume that:

- most of the information regarding the proximate determinants of fertility is derived from the DHS report.

- The source of the initial method mix is also the DHS report.

- The projection of women of reproductive age is taken from a DemProj projection.

- Changes in method mix and other variables are estimated using general patterns described in this section.

- The default values in the model are used for method attributes, such as effectiveness and couple-years of protection.

- Cost per user estimates are derived from the average values presented in this chapter.

The basic model inputs for this example are shown in Tables 24 and 25.

These inputs assume a decline in the percentage of women of reproductive age who are in union as the country develops socially and economically. They also assume that the duration of postpartum infecundability decreases as a result of declines in breastfeeding. Also included are changes in the method mix that are typical for a country undergoing this type of fertility transition. The method mix changes from one dominated by traditional methods when prevalence is low to one where more effective

methods are used by the majority of users. Costs per user are assumed to decline as the program matures.

In this example, the goal is to achieve desired fertility, based on the wanted total fertility rate reported in the DHS final report. We assume that desired fertility will be attained by 2020.

Table 24: Proximate Determinants and Method Mix for Sample Application

	1995	2020
Proximate Determinants		
Number of women of reproductive age	8,400,000	19,200,000
Percent in union	70%	63%
Duration of postpartum infecundability	16 months	13 months
Total abortion rate	0	0
Involuntary sterility	2.2%	2.2%
TFR	6.6	5.1
Contraceptive prevalence	15%	–
Method Mix		
Condom	9.3%	12.9%
Female sterilization	7.8%	11.0%
Injection	2.3%	10.4%
IUD	3.9%	9.2%
Orals	14.0%	28.0%
Traditional	62.7%	28.5%

Table 25: Method Attributes for Sample Application

Method	Effectiveness	Units per CYP	Average Age of Users	Cost per User/Acceptor
Condom	81%	120 units	–	$20/user/year
Female sterilization	100%	–	35.4	$100/acceptor
Injectables	100%	4 injections	–	$20/user/year
IUD	96%	3.5 years per insertion	–	$20/acceptor
Orals	92%	15 cycles	–	$15/user/year
Traditional	50%	–	–	$0

A. Contraceptive Prevalence

The prevalence level in 2020 that is required to achieve this fertility level is calculated by the model to be 34.4 percent, compared to 15 percent in the base year. The increase would have been even higher, except that the shift in method mix away from heavy reliance on traditional methods to more effective methods resulted in the average effectiveness increasing from 66 percent in 1995 to 81 percent by 2020.

B. The Effect of Changes in the Proximate Determinants of Fertility

In order to see the effect of a change in percent in union, postpartum insusceptibility, and method mix, we can compare the prevalence required in the base case with the prevalence requirement if there were no changes in these variables. **Table 26** compares the base case with projections, assuming changes in these variables.

Table 26: Effect on Required Prevalence of Holding Constant the Other Proximate Determinants

Change in Base Projection	Required Prevalence in 2020
Base Projection	34.4%
Constant percent WRA in union	42.4%
Constant postpartum infecundability	26.7%
Constant percent WRA in union and postpartum infecundability	35.5%
Constant method mix	42.3%
Constant method mix, percent WRA in union and postpartum infecundability	43.7%

If the percent in union remained constant while the other two factors changed, as in the base case, the required prevalence would increase to 42.4 percent. Thus, the expected drop in the percent in union, due largely to increasing age at first marriage, would reduce the prevalence required to achieve desired fertility by
19 percent.

If the duration of postpartum infecundability remained constant while the other two factors changed, as in the base case, the required prevalence would be 26.7 percent. This figure is 22 percent lower than the base projection. Clearly, if the expected decline in breastfeeding could be avoided, then the required prevalence would be much less. A program to promote breastfeeding in order to provide health benefits to infants would also have a positive impact on the family planning effort required to achieve desired fertility.

Holding constant both percent in union and postpartum infecundability would result in a required prevalence of 35.5 percent. This is only slightly more than the base case. In this example, changes in marriage patterns and breastfeeding roughly cancel each other out in terms of the effect on required contraceptive prevalence.

If the method mix remained as it was in 1995, then the required prevalence in 2020 would be 42.3 percent instead of 34.4 percent, as in the base case. This difference is due to the increase in the average effectiveness that results when the method mix reflects greater use of modern methods.

If we held all three factors constant, required prevalence would be 43.7 percent in 2020.

C. The Number of Users Required

Although the level of prevalence required would increase by 129 percent, the number of users would increase even more, by 365 percent. This is true because the number of women of reproductive age is also changing during this period, increasing by 125 percent from 1995 to 2020. Perhaps more pertinent to the family planning program is the increase in the number of modern method users. Modern method users represent 37 percent of all users in 1995 but increase to 72 percent by 2020. The **number** of modern method users increases by 800 percent. This is an annual increase of 9.2 percent per year. Thus, the combination of increasing prevalence, growth in the number of women of reproductive age, and the changing method mix results in rapid growth in required family planning services to meet desired fertility by 2020. Growth in the number of users of particular methods is also quite large, especially in the case of injectables.

At this point in the analysis it would be wise to review these results and begin to think about whether such a rapid increase in services is feasible. The following paragraphs investigate further some of the related indicators of family planning service requirements. If, after a review of these results, it appears that the rapid growth rates required do not seem feasible, it may be necessary to either adjust the fertility goal or extend the projection period to accomplish the original fertility goal.

D. The Number of New Acceptors Required

The annual number of new acceptors of female sterilization and IUDs increases from 31,700 in 1995 to 232,000 by 2020. While the share of the mix for both methods is fairly similar, fewer acceptors of sterilization are needed due to the longer-lasting nature of sterilization as compared to the IUD.

E. Total Costs of Family Planning

The total costs of providing these services increase from $5.67 million in 1995 to $18.62 million in 2020, using the cost per user assumptions shown in **Table 27**. The increase in costs averages approximately 9 percent for the first few years, but because the cost per user decreases over time due to the prevalence rise, the annual increase in total costs ranges from 0.5 percent to 1.0 percent by the end of the projection period.

Table 27: Comparison of Costs by Method, 1995 and 2020

Method	Cost/User, 1995 ($)	Cost/User, 2020 ($)
Condom	20.00	5.00
Female sterilization	100.00	50.00
Injections	20.00	10.00
IUD	20.00	15.00
Orals	15.00	5.00

F. Exploring Alternate Program Configurations

Once the initial analysis has been prepared, it can be used to explore the consequences of different program configurations for program goals. Several of the issues that might be investigated using FamPlan are discussed briefly below.

1. Programs to Promote Long-Lasting Methods

A program to promote the use of long-lasting methods could result in increased effectiveness and lower costs. Of course, such a program would only be successful in situations where there was significant demand for limiting births. Users can test the effects of this type of program with FamPlan by changing the method mix. Suppose, for example, that the method mix for 2020 in the sample application were changed to increase female sterilization from 11 to 20 percent and IUD from 10 to 20 percent, and to show a substantial drop in use of traditional methods. The result would be an increase in average effectiveness in 2020 from 81 percent to 90 percent due to increased use of more effective methods. The required prevalence would decrease slightly from 34.4 percent to 30.7 percent.

2. Introduction of New Technology

The next decade may see the introduction of a number of new contraceptive technologies. FamPlan can be used to examine the effects of these new technologies on acceptors and total costs. Suppose, for example, that a new method such as Norplant was introduced in the sample country and that it was expected to provide 10 percent of modern method use by 2020 (substituting equally for the other modern methods). If Norplant were assumed to have a cost per acceptor of $60 by 2020, then the total costs for modern methods in 2020 would be 40 percent greater. The number of Norplant users would rise to 406,000 by 2020.

3. Multiple Method Use

The method mix describes the distribution of users by the main method they use. Generally, the figures for method mix sum to 100 percent, indicating that all users are using one main method. But some users may use multiple methods. Although the prevalence of multiple method use is probably small in most societies, it may increase in the future, particularly as programs are expanded to promote condom use for protection against sexually transmitted diseases, especially AIDS. Although the use of condoms to protect against HIV transmission may not provide much protection against pregnancy, it could be useful to consider the costs of additional condom programs in relation to the family planning program. Users may make this comparison with FamPlan by increasing the percentage of people using condoms without offsetting this increase by decreases in other methods. The method mix will sum to more than 100 percent to reflect the fact that there is considerable multiple method use.

In the sample application used here, the percent using condoms in 2020 could be increased from 13 percent to 23 percent. The result would be a much greater increase in the number of condom users. For example, the total number of users would be 62 percent greater in 2020. This result has many implications for a condoms logistics system.

4. Programs to Promote Breastfeeding

Programs to promote the practice of breastfeeding can have beneficial effects on child survival. They can also affect the requirements for family planning since increased breastfeeding lengthens the period of postpartum infecundability. Users can replicate this effect in FamPlan by lengthening the period of postpartum insusceptibility or by slowing the decrease that might otherwise be expected to take place as the society develops. The result will be a lower level of required prevalence and fewer required users and costs. For example, if the period of postpartum insusceptibility were to remain constant in the sample application, then the required

prevalence would rise to only 27 percent instead of 34 percent. This would mean 22 percent fewer modern method users and a 22 percent reduction in costs in the year 2020.

5. *Programs to Reduce Sterility*

In some countries, high levels of sexually transmitted diseases lead to problems of subfertility and infertility. Programs to detect and treat these diseases can reduce the incidence of pathological sterility in the population. To examine this effect, users may reduce the estimate of sterility. In the sample application, a reduction in the prevalence of sterility from 2 percent to 0.5 percent by 2020 would result in an increase of 6 percent in the required number of users, raising prevalence from 34 percent to 36 percent to attain desired fertility.

6. *Programs to Reduce the Incidence of Abortion*

Although the sample application used here assumes no abortion, in some countries abortion does have a significant affect on the TFR. FamPlan can be used to examine this relationship by way of a change in the assumed abortion rate. For example, the model can be used to determine what amount of additional contraceptive prevalence would be required to achieve the same TFR, if abortions could be eliminated.

7. *Programs to Improve the Quality of Family Planning Services*

Although the quality of services is not easy to measure, there are several indicators in FamPlan that are related to quality of service. The average effectiveness of temporary methods is affected by the degree to which family planning providers ensure that clients understand how to use the method correctly and that the method is appropriate for that client. Model users could at least partially examine the effects of a program to improve quality by increasing effectiveness rates in the model, or by increasing the average duration of use for IUDs or Norplant. For example, an increase in effectiveness for orals and condoms in the sample application would result in a 3 percent reduction in the number of users and a 4 percent reduction in costs by 2020.

8. *Cost Recovery*

Although not considered in this sample application, FamPlan can also be used to examine cost recovery. Initiating or increasing user fees might be one way to improve cost recovery. The model can be used to examine the change in net costs and percentage of costs recovered that result from different levels of user fees. It should be noted, however, that the model does not consider the fact that higher user fees might result in some decline in the demand for family planning services. The relationships between demand and cost need to be considered when FamPlan is being used to examine the impact of cost-recovery programs.

9. *Changes in Source Mix*

Although not examined in this sample application, FamPlan can also be used to investigate the effects of a changing source mix. This change might occur through the introduction of new programs, such as a social marketing program, or through activities to encourage the commercial or NGO sector to expand services. FamPlan could be used to examine the effects of this changing source mix on the number of users and acceptors who would require service from each source. The results might be used to plan for public sector service expansion or to check the feasibility of expanding the private sector rapidly enough to achieve the program goals.

7.3.8   Methodology

The methodology section describes the equations used in FamPlan. The equations differ depending on which of the family planning goals is chosen. The equations are explained first for goal 3 (achieving a specified level of contraceptive prevalence). Then the equations that change when other goals are chosen are explained.

The main calculations in FamPlan are based on the proximate determinants of fertility framework developed by John Bongaarts (Bongaarts and Potter, 1983). This framework has been implemented and explained in Bongaarts (1978) and Bongaarts and Stover (1986).

7.3.8.1   Proximate determinants of fertility

The relationship between the contraceptive prevalence rate and the total fertility rate is based on the proximate determinants of fertility framework developed by John Bongaarts. This framework describes the factors that determine the observed TFR. These factors are:

- Proportion of women of reproductive age in union
- Contraception
- Postpartum infecundability
- Induced abortion
- Sterility
- Frequency of intercourse
- Spontaneous abortion
- Total fecundity rate.

The total fecundity rate is the fertility rate that would be achieved in the absence of any fertility-limiting effect of the proportion in union, contraception, induced abortion, or postpartum infecundability. The other factors all act to produce an observed TFR that is lower than the total fecundity rate.

Applications of this framework generally focus on only the first five of these factors and the total fecundity rate. Variations in the frequency of intercourse are assumed to have a minor effect on TFR, except in cases of spousal separation (where these women can be classified as not in union). Spontaneous abortion is not easily measured. Therefore, in practice, frequency of intercourse and spontaneous abortion are often ignored or combined with the total fecundity rate to produce a single measure.

These modifications to the proximate determinants framework allow us to specify the total fertility rate as a function of six factors: proportion in union, contraception, postpartum infecundability, induced abortion, sterility and the total fecundity rate. Bongaarts developed indices to measure each of these factors.

1. Single Age Group, 15-49

In the aggregate, the use of these six indices yields the following equation:

$$[1] \; TFR_t = Cm_t \bullet Ci_t \bullet Ca_t \bullet Cs_t \bullet Cc_t \bullet TF \quad ,$$

where:

TFR_t = total fertility rate

Cm_t = marriage index

Ci_t = insusceptibility index

Ca_t = abortion index

Cs_t = sterility index

Cc_t = contraception index

TF   = total fecundity

t   = time index.

The index of marriage is simply the percentage of women in the age group who are married or in union:

[2] Cm_t = Percent of women 15-49 in union$_t$.

The index of postpartum infecundability is calculated as the ratio of the average birth interval with and without breastfeeding:

[3] Ci_t = 20.0 / (18.5 + Period of postpartum insusceptibility$_t$)   .

The index of induced abortion is calculated as a function of the total abortion rate, the total fertility rate and the contraceptive prevalence rate:

[4] Ca_t = TFR_{t-1} / {TFR_{t-1} + [0.4 • (1 + $prev_{t-1}$) • TAR_t]}   ,

where:

$prev_t$ = contraceptive prevalence

TAR_t = total abortion rate.

The index of sterility is calculated from the percentage of women in union who remain childless at the end of their reproductive years:

[5] Cs_t = (7.63 - 0.11 • Percent sterile$_t$) / 7.3   ,

where:

Percent sterile$_t$ =   Percentage of women 15-49 who are sterile.

The index for contraception (equation 6) is calculated as a function of the proportion of women using contraception and the effectiveness of the contraception.

[6] Cc = 1 - 1.08 • $prev_t$ • effectiveness$_t$,

where:

$prev_t$ = prevalence of contraception at time t

$effectiveness_t$ = average effectiveness of all methods at time t .

The average effectiveness is a weighted average of the effectiveness of each method and the proportion of users using that method:

$$[7]\ effectiveness_t = (\sum prev_{m,t} \bullet effectiveness_{m,t}) / prev_t \quad ,$$

where:

$effectiveness_{m,t}$ = use effectiveness of method m .

2. Five-Year Age Groups, 15-19, …, 45-49

For five-year age groups, the calculations are similar, but age-specific equations are used to calculate TFR, the contraceptive index and the average effectiveness of contraception (equations 8 through 15). The TFR is a result of the age-specific fertility rates, which were themselves generated by the six age-specific indices.

$$[8]\ TFR_t = 5 \bullet \sum ASFR_{a,t} / 1000 \quad ,$$

where:

$prev_t$ = contraceptive prevalence

t = time index
a = age index from 15-19, 20-24, 25-29, 30-34, 35-39, 40-44, 45-49
$ASFR_a$ = age-specific fertility rate.
$,t$

$$[9]\ ASFR_{a,t} = Cm_{a,t} \bullet Ci_{a,t} \bullet Ca_{a,t} \bullet Cs_{a,t} \bullet Cc_{a,t} \bullet TF_a \quad ,$$

where:

$Cm_{a,t}$ = marriage index

$Ci_{a,t}$ = insusceptibility index
$Ca_{a,t}$ = abortion index
$Cs_{a,t}$ = sterility index
$Cc_{a,t}$ = contraception index

TF_a = total fecundity.

[10] $Cm_{a,t}$ = Percent of women in age group a in union$_t$.

[11] $Ci_{a,t}$ = 20.0 / (18.5 + Period of postpartum insusceptibility$_{a,t}$) .

[12] $Ca_{a,t}$ = $ASFR_{a,t-1}$ / {$ASFR_{a,t-1}$ + [0.4 • (1 + $prev_{a,t-1}$) • $ASAR_{a,t}$]} ,

where:

$prev_{a,t}$ = contraceptive prevalence
$ASAR_{a,t}$ = age-specific abortion rate.

[13] $Cs_{a,t}$ = (7.63 - 0.11 • Percent sterile$_{a,t}$) / 7.3 ,

where:

Percent sterile$_{a,t}$ = percent of women in age group a who are sterile.

[14] $Cc_{a,t}$ = 1 - IC_a • $prev_{a,t}$ • effectiveness$_{a,t}$,

where:

IC_a = infecundability coefficient

a = 15-19, IC = 1.02
a = 20-24, IC = 1.02
a = 25-29, IC = 1.03
a = 30-34, IC = 1.04
a = 35-39, IC = 1.12
a = 40-44, IC = 1.13
a = 45-49, IC = 2.08

effectiveness$_{a,t}$ = average contraceptive effectiveness.

[15] effectiveness$_{a,t}$ = ($\sum$ $prev_{a,m,t}$ • effectiveness$_{m,t}$) / $prev_{a,t}$,

where:

effectiveness$_{m,t}$ = use effectiveness of method m .

7.3.8.2 Method prevalence

The contraceptive prevalence for each method is calculated by multiplying the method mix for each method by the total prevalence for all methods:

$$[16]\ prev_{a,p,t} = MethodMix_{a,m,t} \bullet prev_{a,t} \qquad ,$$

where:

$prev_{a,t}$ = contraceptive prevalence

$MethodMix_{a,m,t}$ = method mix (percent of all users using method m)...

7.3.8.3 Contraceptive users

For users, by methods

The number of users of each method is calculated by multiplying the method prevalence by the number of women of reproductive age who are in union:

$$[17]\ users_{a,m,t} = prev_{a,m,t} \bullet MWRA_{a,t} \qquad ,$$

$$[18]\ MWRA_{a,t} = WRA_{a,t} \bullet percent\ married_{a,t} \qquad ,$$

where:

$users_{a,m,t}$ = contraceptive prevalence

$MWRA_{a,t}$ = method mix (percent of all users using method m)...

$WRA_{a,t}$ = number of women in age group a

For users, by source

Users by source are calculated by multiplying the number of users of each method by the proportion of those users who receive their services from a particular source:

$$[19]\ users_{a,m,s,t} = users_{a,m,t} \bullet SourceMix_{m,s,t} \qquad ,$$

where:

s = source of services

$SourceMix_{m,s,t}$ = proportion of users receiving their services from source s .

7.3.8.4 Contraceptive acceptors

The number of new acceptors of contraceptive methods (equation 20) is determined only for the long-term methods: sterilization, IUD and Norplant. Acceptors are the number of new users that must be added during a year to achieve the required number of users by the beginning of the next year. Acceptors are calculated as the number of new users required to achieve the specified growth in total users (users next year minus users this year) plus the number of new users required to replace those that discontinue use, age out of the age group, or die, minus the number of current users aging into the age group.

Note: Acceptors and discontinuers are used in both equation 20 and equation 21. The calculating equation for acceptors is actually:

$$[20] \; acceptors_{a,m,t} = \; (\; users_{a,m,t+1} - users_{a,m,t} + users_{a,m,t} \bullet DiscontinuationRate_{m,t} + AgingOut_{a,m,t} + deaths_{a,m,t} - AgingIn_{a,m,t}) / (1 - DiscontinuationRate_{m,t} / 2) .$$

$$[20] \; acceptors_{a,m,t} = \; users_{a,m,t+1} - users_{a,m,t} + discontinuers_{a,m,t} + AgingOut_{a,m,t} + deaths_{a,m,t} - AgingIn_{a,m,t} \quad ,$$

where:

$acceptors_{a,m,t}$ = source of services

$discontinuers_{a,m,t}$ = proportion of users receiving their services from source s.

$AgingOut_{a,m,t}$ = number of current users of method m aging out of age group a

$AgingIn_{a,m,t}$ = number of current users of method m aging into age group a.

The number of people discontinuing use of a method (equation 21) is calculated as the number of users at the beginning of the year multiplied by the discontinuation rate (to determine the number of users at the beginning of the year who discontinue) plus the number of new acceptors during the year multiplied by one-half the discontinuation rate (since new acceptors are assumed to be subject to discontinuation as well, but for only half a year since, on average, they will be users for only half a year). The discontinuation rate is approximated by the reciprocal of the average duration of use (equation 22). Discontinuation is calculated only for the IUD and Norplant since sterilization is considered permanent.

$$[21] \; discontinuers_{a,m,t} = users_{a,m,t} \bullet DiscontinuationRate_{m,t} + acceptors_{a,m,t} \bullet DiscontinuationRate_{m,t} / 2 \quad ,$$

$$[22] \; DiscontinuationRate_{m,t} = 1 / duration_{m,t} \quad ,$$

where:

$DiscontinuationRate_{m,t}$ = percentage of users of method m stopping use during the year

$duration_{m,t}$ = the average duration of use, measured in years.

The number of users who die each year (equation 23) is calculated as the number of users multiplied by the female annual death rate. This calculation assumes that contraceptive users experience the same mortality as all women of the same age. This assumption slightly overstates the mortality rate since users are less likely to experience a death due to birth complications, but the overall effect is minor. For the single age group projection, this assumption will slightly understate the actual mortality since contraceptive users will be somewhat older than all women in the 15-49 age group.

[23] $deaths_{a,m,t} = users_{a,m,t} \bullet FemaleMortalityRate_{a,t}$,

where:

$FemaleMortalityRate_{a,t}$ = proportion of females in age group a who die each year.

The number of users who age out of the age group each year (equation 24) is simply the number in the last age in the age group (e.g., those aged 29 are in the last year of the 25-29 age group) in the previous year. This figure is approximated by the average number of people in the age group of interest and the next older age group. This arrangement assumes that the progression is roughly linear from the youngest single age in the age group of interest to the oldest single age in the next older age group.

[24] $AgingOut_{a,m,t} = (users_{a,m,t} + users_{a+1,m,t}) / 10$.

The number of users aging into the age group is simply the number aging out of the next younger age group, except for the youngest age group, which has no users aging in:

[25] $AgingIn_{a,m,t} = AgingOut_{a-1,m,t}$.

When the single age group option is being used, a different approach is required. In this case we assume that the number of users aging past 49 is negligible for the IUD and Norplant. For sterilization, we employ a regression equation that uses the average age at the time of sterilization to estimate the percentage of all sterilization users who are 49 (equations 26 and 27).

[26] $AgingOut_{m,t} = users_{m,t} \bullet Percent49_{m,t}$

[27] $Percent49_{m,t} = e^{0.1577 \bullet AverageAge_{m,t} - 3.1831}$.

The number of acceptors by source is calculated by multiplying the number of acceptors by the proportion of users receiving their services from each source:

[28] $acceptors_{a,m,s,t} = acceptors_{a,m,t} \bullet SourceMix_{m,s,t}$.

7.3.8.5 Commodities required

For long-term methods

For the long-term methods (sterilization, IUD, Norplant), the commodities required are equal to the number of acceptors:

[29] $Commodities_{m,s,t} = acceptors_{m,s,t}$.

For short-term methods

For the temporary methods, commodities are calculated by multiplying the number of users by the number of units per users:

[30] $Commodities_{m,s,t} = users_{m,s,t} \bullet UnitsPerUser_{m,s,t}$,

where:

$Commodities_{m,s,t}$ = number of commodities required

$UnitsPerUser_{m,s,t}$ = commodity units per user.

7.3.8.6 Expenditure required

The gross expenditure required is calculated by multiplying the number of users or acceptors of each method and source by the cost per user or acceptor for that source.

For temporary methods: Expenditure

Expenditure required for the temporary methods (condom, injectable, pill, vaginal barrier, vaginal tablets, other) is based on the number of users:

[31] $GrossExpenditure_{m,s,t} = users_{m,s,t} \bullet CostPerUser_{m,s,t}$.

For long-term methods: Expenditure

The expenditure required for long-term methods (sterilization, IUD, Norplant) is based on the number of acceptors:

[32] $GrossExpenditure_{m,s,t} = acceptors_{m,s,t} \bullet CostPerAcceptor_{m,s,t}$,

where:

$GrossExpenditure_{m,s,t}$ = gross expenditure required

$CostPerUser_{m,s,t}$ = cost per user

$CostPerAcceptor_{m,s,t}$ = cost per acceptor.

Net expenditure is calculated by subtracting recovered costs from the gross expenditures:

[33] $NetExpenditure_{m,s,t} = GrossExpenditure_{m,s,t} - CostsRecovered_{m,s,t}$,

where:

$NetExpenditure_{m,s,t}$ = net expenditure for family planning services

$CostsRecovered_{m,s,t}$ = revenue from service fees.

For long-term methods: Revenue

For long-term methods, the revenue from services is calculated by multiplying the number of acceptors by the fee per acceptor:

[34] $CostsRecovered_{m,s,t} = acceptors_{m,s,t} \bullet FeePerAcceptor_{m,s,t}$,

where:

$FeePerAcceptor_{m,s,t}$ = fee charged per acceptor.

For temporary methods: Revenue

For the temporary methods, the revenue from services is calculated by multiplying the commodities required by the fee per unit:

[35] $CostsRecovered_{ms,t,} = Commodities_{m,s,t} \bullet FeePerUnit_{m,s,t}$,

where:

$UnitsPerUser_{m,t}$ = number of commodity units per user

$FeePerUnit_{m,s,t}$ = fee charged per unit

7.3.8.7   Goal 1 - Reducing unmet need for contraception

Additional inputs required for goal 1 are:

1. Prevalence in the base year by spacing and limiting

2. Unmet need in the base year by spacing and limiting

3. The proportion of unmet need that is meet by spacing and limiting by year

4. Method mix by spacing and limiting.

When the goal is reducing unmet need, then the prevalence goal and the method mix are specified by spacing and limiting purposes. In this case, the method prevalence equation is modified. The method prevalence becomes the weighted average of the spacing and limiting method prevalence:

$$[41] \; prev_{a,p,t} = (\sum MethodMix_{a,p,m,t} \bullet prev_{a,p,t}) / prev_{a,t} \quad ,$$

where:

$prev_{a,p,t}$ = prevalence for purpose p

p = purpose of contraception; s = spacing; l = limiting

$MethodMix_{a,p,m,t}$ = method mix (percentage of all users using method m).

The calculation of pregnancies is also modified for this option. In this case, pregnancies can be either wanted, unwanted, or mistimed. Unwanted or mistimed pregnancies are those that occur because of method failure or that occur to women with an unmet need for contraception. Pregnancies due to method failure are considered to be unwanted if they occur to women who are limiters, or are considered to be mistimed if they occur to women who are spacers. Similarly, pregnancies to women with an unmet need for limiting are considered to be unwanted and those occurring to women with an unmet need for spacing are assumed to be mistimed.

Pregnancies as a result of method failure are calculated by multiplying the number of women using spacing or limiting methods by the average failure rate (equations 42 and 43).

$$[42] \; UnwantedPregnancies_{failure,a,t} = (prev_{limiting,a,t} \bullet MWRA_{a,t}) \bullet (1 - effectiveness_{limiting,a,t}) ,$$

$$[43] \; MistimedPregnancies_{failure,a,t} = prev_{spacing,a,t} \bullet MWRA_{a,t}) \bullet (1 - effectiveness_{spacing,a,t}) ,$$

where:

$UnwantedPregnancies_{failure,a,t}$ = unwanted pregnancies due to method failure

$MistimedPregnancies_{failure,a,t}$ = mistimed pregnancies due to method failure.

Pregnancies occurring to women with an unmet need are also assumed to be unwanted or mistimed. The number of these pregnancies is calculated as the difference between the actual number of pregnancies and the number of pregnancies there would be if prevalence were increased to current prevalence plus unmet need. The first step is to calculate prevalence:

$$[44] \; NeededPrev_{a,t} = prev_{a,t} + UnmetNeed_{a,t} \quad ,$$

where:

$NeededPrev_{t}$ = prevalence needed to eliminate unmet need

$UnmetNeed_{a,t}$ = proportion of women in union with an unmet need.

Next, the proximate determinants equation is used to calculate the difference in fertility. This is illustrated in equation 45 for the case of a single age group. This equation accommodates changes in the population's underlying susceptibility to a pregnancy.

[45] TFR_t - $TFRwithNoUnmetNeed_t$ =

$$Cm_t \bullet Ci_t \bullet Ca_t \bullet Cs_t \bullet TF \bullet (1\text{-}1.08 \bullet prev_t \bullet effectiveness_t) \text{-}$$

$$Cm_t \bullet Ci_t \bullet Ca_t \bullet Cs_t \bullet TF \bullet (1\text{-}1.08 \bullet NeededPrev_t \bullet effectiveness_t) \text{,}$$

where:

$TFRwithNoUnmetNeed_t$ = TFR if there were no unmet need.

Next, pregnancies due to unmet need ($Pregnancies_{UnmetNeed,t}$) are calculated from the difference in TFR:

[46] $Pregnancies_{UnmetNeed,t}$ = (TFR_t - $TFRwithNoUnmetNeed_t$) $\bullet$ WRA_t / 35

This approach is used to calculate pregnancies due to unmet need for limiting (unwanted pregnancies) and those due to unmet need for spacing (mistimed pregnancies).

7.3.8.8   Pregnancies

For total pregnancies

The total fertility rate is used in the demographic module to calculate the total number of live births. The number of pregnancies is estimated as the number of live births plus the number of spontaneous and induced abortions. Spontaneous abortions are assumed to average 13 percent of pregnancies. Therefore, total pregnancies are calculated as births plus induced abortions divided by 1 - 0.13:

[36] $pregnancies_{a,t}$ = ($births_{a,t}$ + $InducedAbortions_{a,t}$) / (1 - 0.13) ,

where:

$pregnancies_{a,t}$ = number of pregnancies

$births_{a,t}$ = number of live births

$InducedAbortions_{a,t}$ = number of induced abortions.

For unwanted pregnancies

Pregnancies can be either wanted or unwanted. In goal 3 of FamPlan, we are interested only in unwanted pregnancies that occur because of method failure ($UnwantedPregnancies_{a,t}$). Pregnancies

as a result of method failure are calculated by multiplying the number of women using contraception by the average failure rate:

$$[37]\ UnwantedPregnancies_{a,t} = (\ prev_{a,t} \bullet MWRA_{a,t}\ ) \bullet (\ 1 - effectiveness_{a,t}\ )$$

7.3.8.9   Abortion

There are two options to determine abortions. If the total abortion rate is entered, then induced abortions are calculated directly.

For single age group

$$[38]\ InducedAbortions_t = TAR_t \bullet WRA_t / 35 \quad .$$

For five-year age groups

$$[39]\ InducedAbortions_{a,t} = ASAR_{a,t} \bullet WRA_{a,t} / 1000 \quad ,$$

where:

$ASAR_{a,t}$ = age-specific abortion rate.

The second option is to calculate abortions as a percentage of the number of unwanted pregnancies.

$$[40]\ InducedAbortions_{a,t} = UnwantedPregnancies_{a,t} \bullet PercentTerminated_{a,t} \quad ,$$

where:

$PercentTerminated_{a,t}$ = percentage of unwanted pregnancies terminated by abortion.

7.3.8.10   Goal 2 - Total wanted fertility

If goal 2 is selected, users will be required to enter the current TFR, the desired TFR, and the percent reduction in the difference between the actual and desired TFR to be achieved in each year. The first step in the calculations is to determine the TFR goal for each year:

$$[47]\ TFR\_goal_t = TFR_{t=1} - (\ TFR_{t=1} - DesiredTFR\ ) \bullet PercentReduction_t \quad ,$$

where:

TFR_goal_t = TFR goal for year t

$DesiredTFR$ = desired TFR

$PercentReduction_t$ = percentage reduction in gap between actual and desired TFR.

Once the TFR goal is known, the required contraceptive prevalence is calculated from the proximate determinants of fertility. Equation 1 is rearranged to solve for prevalence rather than TFR:

$$[48]\ prev_t = (\ 1 - TFR\_goal_t / (Cm_t \bullet Ci_t \bullet Ca_t \bullet Cs_t \bullet TF)) / (1.08 \bullet effectiveness_t)$$

7.3.8.11 Goal 4 - Reaching a goal for total fertility rate

The calculations for this goal are the same as for goal 2 (achieving desired fertility) except that the total fertility rate is already given and does not need to be calculated from the desired fertility rate.

7.3.9 Fertility level

A family planning projection may require an assumption about the total fertility rate if the goal is to achieve a certain TFR or to reduce the difference between the desired TFR and the actual TFR. (For other goals, the TFR is calculated as an output of the projection.)

Base Year Estimates of the Total Fertility Rate

The TFR is the number of live births a woman would have if she survived to age 50 and had children according to the prevailing pattern of childbearing at each age group. It is a synthetic measure since no individual woman will necessarily have this number of children (since it is usually not a whole number of births) and it is not an average of the number of live births for currently living women. Rather, it expresses the current level of fertility in terms of the average number of live births that would occur per woman if the current age-specific fertility rates remained constant and all women survived to age 50.

Estimates of the TFR are available from a number of sources. The best sources will be national fertility surveys, which have been conducted by most countries. A large number have been conducted under a series of international projects, including the Demographic and Health Surveys (DHS), the Centers for Disease Control and Prevention (CDC) Fertility Surveys, the Contraceptive Prevalence Surveys (CPS) and the World Fertility Surveys (WFS). Information from these and other national surveys is collected and reported in a variety of sources, including summary reports from the DHS, the Population Reference Bureau's *World Population Data Sheet*, and the *World Development Indicators* from the World Bank. Internet sources of information include the U.S. Census Bureau (http://www.census.gov/ipc/www/), and Macro International (http://www.macroint.com/dhs/).

Future Assumptions of the Total Fertility Rate

There are several means by which a TFR goal may be selected.

1. **National projections.** Many countries have official population projections that include assumptions about the future course of TFR, often with several variants. If population projections are being made for planning purposes, it is often recommended that the official assumptions and projections be used.

2. **National goals.** Many countries have national population goals that often include TFR. It is often useful to use these goals as a starting point for projections. One projection may assume that the TFR goal is achieved, while others may examine the effects of a delay in achieving the goal. Sometimes goals are expressed in terms of crude birth rates, population growth rates, or contraceptive prevalence rates instead of TFR. In these cases, different TFR assumptions may be tried to discover a TFR projection that is consistent with the national goals for these other indicators.

3. **United Nations projections.** The population projections prepared by the United Nations Population Division and reported in *World Population Prospects* include three assumptions (low, medium and high) about future fertility for each country included in the report. These fertility assumptions may be used. The disadvantage to using these projections is that it is not clear what "low," "medium" and "high" mean. The U.S. Census Bureau projections also contain a set of TFR assumptions.

4. **Recent trends and international experience.**
If information is available on TFR for several years, it may be useful to analyze the trends in TFR and develop a future assumption based on continuing past trends. It should be noted, however, that past trends cannot be expected to continue for very long into the future. TFR rarely declines at a constant pace throughout an entire demographic transition. Rates of decline are often slow at first, increase during the middle of the transition, and slow again as they approach replacement-level fertility. **Table 1** shows the experience with fertility decline for a number of countries with good estimates of fertility from two different years.

Table 1: Historical Declines in TFR for Selected Countries

Country	First Year	TFR	Second Year	TFR	5-Year Change*
HIGH FERTILITY COUNTRIES					
Yemen	1991/92	7.70	1997	6.50	-1.09
Uganda	1988	7.40	2000/01	6.90	-0.20
Mali	1987	7.10	2001	6.80	-0.11
Niger	1992	7.00	1998	7.20	0.17
Malawi	1992	6.70	2000	6.30	-0.25
Kenya	1989	6.70	2002	4.90	-0.69
Jordan	1983	6.60	2002	3.70	-0.76
Burkina Faso	1992/93	6.50	1998/99	6.40	-0.08
Zambia	1992	6.50	2001/02	5.90	-0.32
Ghana	1988	6.40	2003	4.40	-0.67
Togo	1988	6.40	1998	5.20	-0.60
Senegal	1986	6.40	1997	5.70	-0.32
Tanzania	1992	6.20	1999	5.60	-0.43
Rwanda	1992	6.20	2000	5.80	-0.25
Eritrea	1995	6.10	2002	4.80	-0.93
Madagascar	1992	6.10	1997	6.00	-0.10
Benin	1996	6.00	2001	5.60	-0.40
Nigeria	1990	6.00	1999	4.70	-0.72
Morocco	1979/80	5.90	2003/04	2.50	-0.71
Cameroon	1991	5.80	1998	4.80	-0.71
Average for high-fertility countries		6.49		5.49	-0.46

MEDIUM FERTILITY COUNTRIES

Guatemala	1987	5.50	1998/99	5.00	-0.22
Pakistan	1990/91	5.40	2000/01	4.80	-0.30
Namibia	1992	5.40	2000	4.20	-0.75
Zimbabwe	1988	5.40	1999	4.00	-0.64
Cote d'Ivoire	1994	5.30	1998/99	5.20	-0.11
Egypt	1980	5.30	2003	3.20	-0.46
Bolivia	1989	5.00	1998	4.20	-0.44
Haiti	1994/95	4.80	2000	4.70	-0.09
Myanmar	1983	4.73	1996	2.91	-0.70
Nepal	1996	4.60	2001	4.10	-0.50
Uzbekistan	1993	4.30	2002	2.90	-0.78
Philippines	1993	4.10	1998	3.70	-0.40
Peru	1986	4.10	2000	2.80	-0.46
Average for medium-fertility countries		**4.92**		**3.98**	**-0.45**
LOW FERTILITY COUNTRIES					
Dominican Republic	1986	3.70	1999	2.70	-0.38
Mexico	1992	3.65	1995	3.43	-0.37
Nicaragua	1998	3.60	2001	3.20	-0.67
Bangladesh	1993/94	3.40	1999/00	3.30	-0.08
India	1992/93	3.40	1998/99	2.80	-0.50
Brazil	1986	3.40	1996	2.50	-0.45
Indonesia	1987	3.30	2002/03	2.60	-0.23
Colombia	1986	3.20	2000	2.60	-0.21
Kazakhstan	1995	2.50	1999	2.00	-0.63
Turkey	1993	2.50	1998	2.60	0.10
Average for low-fertility countries		**3.27**		**2.77**	**-0.34**

*Interval is only 4.5 years for Cote d'Ivoire, 4 years for Kazakhstan, and 3 years for Mexico and Nicaragua; all others are 5+ years.

Source: Demographic and Health Surveys.

5. **Socioeconomic development and population program effort.** Studies have shown that the pace of fertility decline is related to the level of socioeconomic development of a country and the amount of effort put into the family planning program (Bongaarts, Mauldin, and Phillips 1990). These studies are summarized in **Table 2**; e.g. Mexico declined by 0.37 child (from 3.12 to 2.75). TFR declines were greatest in the six middle cells, for the two middle SES groups and the three highest effort ratings. The top SES group declined less since most of its declines already occurred in prior decades. Average declines were least in the lowest SES group (0.29) and weakest effort group (0.27). This may help to develop TFR assumptions for your projections.

Table 2: Declines in TFR in 1990s by Level of Program Effort During 1994-1999 and Socioeconomic Setting

Socioeconomic Setting	Program Effort, 1994-1999								Overall Average
	Strong		Moderate		Weak		Very Weak/None		
High	Mexico	0.37	Chile	0.10	Brazil	0.25	Costa Rica	0.36	
	Mauritius	0.24	Trinidad	0.45			Uruguay	0.09	
	Colombia	0.21	and Tobago				Venezuela	0.31	
	Jamaica	0.26	Panama	0.08			Argentina	0.21	
	Korea, Rep	0.18	Uzbekistan	0.72			Kazakhstan	0.36	
	Malaysia	0.36	*Average*	*0.34*			*Average*	*0.27*	High
	Average	*0.27*							0.28
Upper Middle	Tunisia	0.81	Dominican	0.28	Ecuador	0.42	Guyana	0.10	
	Sri Lanka	0.30	Republic		Namibia	0.45	Mongolia	0.70	
	Iran	1.80	Syria	0.79	Lebanon	0.54	*Average*	*0.40*	
	Peru	0.50	Turkey	0.40	Jordan	0.76			
	Thailand	0.15	Algeria	0.97	Oman	1.05			
	Average	*0.71*	Egypt	0.49	Paraguay	0.38			
			El Salvador	0.35	Nicaragua	0.49			Upper
			Philippines	0.50	Honduras	0.62			Middle
			South Africa	0.50	*Average*	*0.59*			0.58
			Average	*0.54*					
Lower Middle	India	0.35	Ghana	0.70	Bolivia	0.48	Congo	-	
	Zimbabwe	0.60	Senegal	0.66	Zambia	0.20	Nigeria	0.46	
	Morocco	0.55	Pakistan	0.35	Guatemala	0.47	Mauritania	0.10	
	Kenya	0.80	Lesotho	0.38	Cameroon	0.60	*Average*	*0.19*	
	China	0.12	*Average*	*0.52*	Côte d'Ivoire	0.70			
	Indonesia	0.40			*Average*	*0.49*			Lower
	Vietnam	0.80							Middle
	Average	*0.52*							0.46
Low	Bangladesh	0.45	Mali	-	Uganda	-	Benin	0.40	
			Tanzania	0.40	Malawi	0.30	Ethiopia	0.30	
			Nepal	0.30	Niger	-	Mozambique	0.30	
			Average	*0.23*	Central		Madagascar	0.10	
					African		Chad	-	
					Republic	0.30	Yemen	0.50	
					Haiti	0.40	Laos	0.50	
					Average	*0.20*	Sudan	0.40	
							Cambodia	0.20	Low
							Average	*0.30*	0.27
Overall Average		0.49		0.44		0.44		0.28	0.41

Source: Ross and Stover, 2001.

6. **Socioeconomic status**. An alternative method of estimating a likely decline in the fertility rate is to examine TFR by socioeconomic status. National fertility surveys usually report TFR by urban/rural residence and education. Typically, TFR is lower for urban women than for rural women, and lower for women with more than a primary education. If we can estimate the proportion of women who will be urban residents or who will have more than primary education in the target year, a new estimate of TFR can be prepared, assuming that TFR remains constant by socioeconomic group. For example, assume that the TFR is 4 for urban women and 6 for rural women, and that 30 percent of the population is urban. The total TFR will be 5.4. If it is expected that in the target year, 50 percent of the population will be urban, and that the new urban migrants will adopt the behavior of current urban dwellers, then the TFR will drop to 5.0

(0.5 x 4 + 0.5 x 6). This approach will indicate the decline in TFR that might be expected from development alone, without a significant increase in family planning efforts.

7.3.10 Glossary of terms

Some of the following terms were obtained from the Population Reference Bureau's *Population Handbook* (1989); others were adapted from the International Union for Scientific Study of Population's (IUSSP's) *Multilingual Demographic Dictionary* (Van de Walle and Henry, 1982); while still others are definitions employed by the Demographic and Health Surveys program executed by Macro International. These terms are defined in the context of their use within FamPlan.

Abortions. The number of induced abortions occurring during the year.

Acceptors. The number of new users of a particular method in a particular year. A woman is classified as an acceptor if she starts using a method during the year and was not using that method at the start of the year. Previously she may have been using nothing or she may have been using a different method.

Aggregation. A group of elements to be considered as a whole, such as women of reproductive age.

Appropriate method mix. The distribution of contraceptive methods which correspond to the individual fertility intentions and personal characteristics of a population of women.

Births. The number of live births occurring during a year.

Cohort. A group of persons who experience certain events within a specified period of time, such as those who are born or who are married in the same year.

Commodities. The amount of supplies required for different methods to provide a specified level of family planning services. Commodities are expressed in terms of numbers of condoms, sterilization kits, injectable vials, IUDs, Norplant implants, pill cycles and vaginal tablets.

Contraceptive prevalence. The percentage of women of reproductive age using some form of contraception. Most commonly, prevalence is given for women in unions.

Cost per user. The public sector cost of providing family planning, per family planning user.

Couple-year of protection. The number of units of a contraceptive needed to provide protection from pregnancy for one couple for an entire year. For example, 13 units of oral contraceptives are needed to provide one couple with a full year of protection.

Desired fertility rate. The desired fertility rate is an indicator similar to the total fertility rate. It indicates the average number of children that a woman would have *if her expressed fertility desires were achieved*.

Dialogue box. A box (shown on the computer screen) permitting users to choose among a limited number of options. The box is accompanied by text elaborating on those options.

Disaggregation. A group of elements broken down into subsets, such as a population broken down into single-age categories (ages 1, 2, 3, etc.)

Effectiveness. Effectiveness is the extent by which a contraceptive method lowers the chances to become pregnant in a given month. This measure depends both on the ability of women to conceive and on the method's failure rate.

Fecundity. The calculated total fecundity rate. Total fecundity is the average number of children that would be born to women if none of the proximate determinants was acting to reduce fertility from its biological maximum. In the model, fecundity is calculated for the base year only. It remains constant in all other years.

Gross cost. The total public sector cost of providing family planning services.

Growth rates. The increment in total number of contraceptive users from year to year. These are net figures, consisting of new users and the continuing users who remain after previous users either have discontinued or have "aged out."

Interpolation. Given two numbers that serve as boundary points, the estimation of values that lie at intervals between the two points. For example, if the total fertility rate for a country or region was actually measured only in 1980 and in 1995, by assigning a relationship between the values from year to year, it is possible to estimate a TFR for each intervening year. (Spectrum uses a linear form of interpolation so that the difference between each annual value is the same. Other nonlinear forms of interpolation also are possible, but are not used in Spectrum.)

MWRA. The number of women of reproductive age who are married or in union.

Method mix. The distribution of contraceptive users by contraceptive method.

Mistimed pregnancy. Pregnancies which were wanted to occur, but at a time other than the time of their conception.

Model. Computer system designed to demonstrate the probable effect of two or more variables that might be brought to bear on an outcome. Such models can reduce the effort required to manipulate these factors and present the results in an accessible format.

Module. Synonym for "model."

Net cost. The net public sector cost of family planning services. This figure is equal to gross cost minus revenue collected.

Normalization. The transformation of a series of data points into a percent distribution summing to 100 percent.

Pop-up menu. A menu (shown on the computer screen) from which users can select items or actions. Pop-up menus can appear anywhere on the screen.

Postpartum insusceptibility. The period after a birth during which a woman is not exposed to the risk of pregnancy either because of postpartum amenorrhea or because of postpartum abstinence.

Pregnancies. The number of pregnancies occurring during a year. Pregnancies can be wanted, wanted later, or not wanted.

Proximate determinants. Variables which directly impinge on fertility outcomes; these variables include the proportion of women in sexual union, the duration of the period of inability to conceive following a birth, and the level and quality of contraceptive practice?and to a lesser degree, the underlying capability to conceive, the level of induced abortion, and the prevalence of pathological sterility.

Pull-down menu. A menu (shown on the computer screen) opened by clicking on key words at the top edge of the screen. Pull-down menus allow users to select operations.

Radio button. These buttons (shown on the computer screen) emulate raised buttons on early radios, which were punched to select radio stations. The graphically portrayed raised "radio buttons" on interfaces permit users to select among at least three alternatives.

Revenue. The total amount of revenue collected from fees for family planning services.

Total abortion rate. The average number of induced abortions a woman would have if she survived to age 49 and had abortions at the prevailing age-specific rates. Thus, in concept, it is similar to the total fertility rate.

Total fertility rate. The average number of children that would be born alive to a woman (or a group of women) during her lifetime if she were to pass through all her childbearing years conforming to the age-specific fertility rates of a given year.

Unmet need. Refers to couples who presumably should be using contraception based on their fertility desires and susceptibility to a pregnancy, but are not using contraception.

Unwanted pregnancy. Either a pregnancy that occurs due to method failure, or simply one that occurs to a woman who did not want to become pregnant at the time she conceived.

Users. The number of women who are using some form of contraception.

Wanted pregnancies. Calculated as the total pregnancies which were wanted at the time of conception or were wanted to occur at a later time.

Wanted total fertility rate. An indicator similar to the total fertility rate. The wanted total fertility rate is calculated as the level of fertility that would have prevailed during the past few years if all unwanted births had been prevented. (See also desired fertility rate.)

WRA. The number of women of reproductive age, 15-49.

7.3.11 Acronyms and abbreviations

CBD community-based distribution

CDC U.S. Centers for Disease Control and Prevention

CPS Contraceptive Prevalence Survey

CYP couple-year of protection

DHS Demographic and Health Survey

GDP gross domestic product

ICPD International Conference on Population and Development, Cairo, 1994

IUD intrauterine device

MWRA married women of reproductive age

NGO nongovernmental organization

PPI postpartum insusceptibility

TFR   total fertility rate

UN   United Nations

USAID United States Agency for International Development

VFT   vaginal foaming tablet

WFS   World Fertility Survey

WRA   women of reproductive age

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7.4 LiST
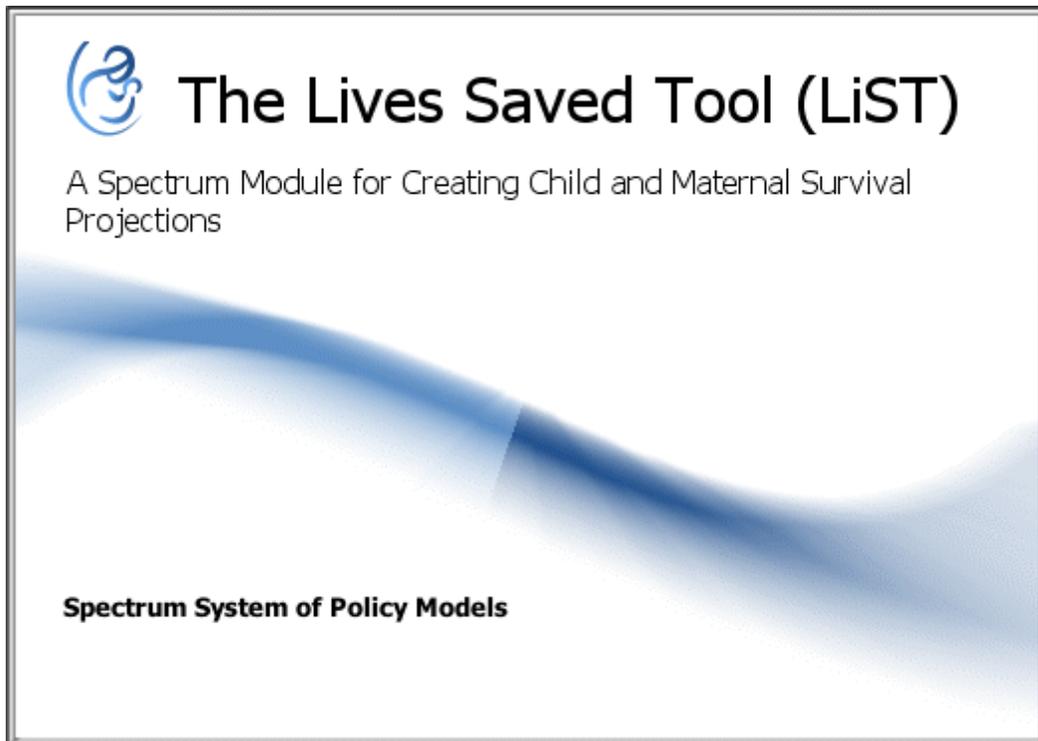
7.4.1 What is LiST?

The Lives Saved Tool (LiST) is computer-based application for modeling the impact of maternal and child health interventions. LiST is included as a module within Spectrum, a policy modeling system comprised of several software components. To estimate maternal, child, or stillbirth outcomes in a projection, LiST models changing coverage for a wide range of maternal and child health interventions over time combined with inputs from the following Spectrum modules: *DemProj*, the demography module, provides demographic information for the projection; *AIM* (AIDS Impact Module), incorporates the impact of HIV/AIDS and trends in HIV/AIDS treatment; and *FamPlan* incorporates determinants of fertility into the projection.

LiST is based on the initial work of the Bellagio Child Survival Study Group, the Child Health Epidemiology Reference Group (CHERG), and the International Child Development Steering Group. Their work has sought to further specify the global burden of disease for neonates and children under five years of age both by region and by cause, and to identify and assess those interventions that will be the most effective in increasing child survival and developmental potential. This work has been published in *The Lancet*'s global health series on child survival, neonatal survival, maternal survival, and infant and young child nutrition.

LiST allows for detailed editing of projection inputs such as: intervention coverage by year, baseline health status, child and maternal mortality rates, stillbirth or abortion information, economic status data, effectiveness of interventions, and the impact of undernutrition on mortality. Subnational projections for LiST may be created by making modifications to related components in LiST as well as DemProj, AIM, and FamPlan.

The LiST module is a work in progress that is continuously adapting to meet the needs of users in countries, institutions, and partner organizations. LiST has been used for global planning, project planning, and project evaluation purposes. In addition to updates for nutrition indicators and interventions, the components for maternal health and stillbirths and the ability to link to an external costing module are now included.

Please visit www.livessavedtool.org for further information and resources. You can also view the following training video: Introduction to the Lives Saved Tool (26 minutes).

7.4.2   Standard LiST analysis

Overview of Basic Analysis

1. Create or edit a projection so it contains all of the appropriate baseline data. You can do so by clicking on "Configuration" and "Health status, mortality and economic status." Save this with a name which indicates that it is your baseline projection. This projection will be your counterfactual or do-nothing scenario, so that you can compare your scale-up projection to this reference.

2. Open the baseline projection and use "Save as" to save a second file, renaming it as the scale-up of interest. Edit the coverage values in "Coverage" to create the scale-up as desired. Save these changes. Check the results by looking at the "Additional deaths prevented in children under five years of age by intervention relative to impact year" to ensure that only the interventions that you have scaled updisplay any changes (excluding the HIV interventions) and that the first year ("impact year") has 0 deaths averted. Correct as needed. When finished save changes and close the projection.

3. Repeat step 2 as many times as necessary to create all the comparisons of interest.

4. Open the baseline projection and additional projections of interest so that their results can be displayed simultaneously for easy comparison. They will only open if the configuration years and modules are identical for all projections.

5. Display the results and right-click to choose "copy all" in order to copy the relevant tables into Excel. Figures can also be exported by copying and pasting to Word, Excel, or PowerPoint.

Detailed Steps for Basic Analysis

1. Click "New projection" or "Open projection" to create or edit a projection. For a new projection, you will need to set the following: projection file name, first and final years for the projection, active modules (select LiST and any others of interest), and the country or global region of interest.

2. Click the "Modules" tab on the top toolbar and click "LiST" under the MNCH options. A horizontal toolbar will appear directly below the menu tabs.

3. Select "Configuration" from the horizontal toolbar, the first item from the left-hand side.

4. "Base year of coverage" is set by default to the first year of the projection; change if needed. Note that if you select a base year that is in the future, LiST will use the most recent available data.

5. The "First year of intervention program" refers to the baseline year from which you are calculating the impact of a specific coverage change (i.e., for a program to introduce rotavirus vaccine starting in 2012, the first year of intervention program would be 2011).

NOTE: It is always a good idea to save your changes as you go along to prevent the loss of data. Remember to "Save as" when you start working on a new projection so you can return to your original projection if needed.

6. Select "Health status, mortality, and economic status" from the horizontal toolbar, the second item from the left-hand side. Make any modifications necessary to the default baseline data.

7. Select "Coverage" from the horizontal toolbar, the third item from the left-hand side.

8. Edit the coverage values from the baseline year to the first year of intervention. To change the coverage values independently for items which are linked to other coverage values, see the bottom of the coverage editor as to which box to uncheck. This will de-link the items.

9. Edit the coverage values from the first year of intervention to the target/end year. An easy way to change this coverage is to set a coverage level in the target year, and then highlight the row from the first year of intervention to the target year. Then click the "Interpolate" button displayed at the bottom of the screen (or press Ctrl+I) to create a linear trend between the first and last years (or right-click and choose "Interpolate" from the pop-up menu for more options).

10. Click on the "File" menu and choose "Save As." You now have your "Scenario 1" projection.

11. If you would like to create alternate scenarios to compare against Scenario 1, you can do this by using "Save As" to rename this projection to indicate it is a comparison to Scenario 1 (e.g., Senegal Scenario 2 - Vaccines).

12. Do not change the baseline health, mortality, or economic status from Scenario 1, or the intervention coverage levels in the baseline year. Otherwise Scenario 2 will not compare accurately against Scenario 1 in terms of the impact of changes in intervention coverage. When you have finished all coverage changes, click OK. Be sure to save your work on Scenario 2.

13. Repeat as many times as necessary to create alternate comparisons. Please note, when you are working with multiple projections, be sure that you are editing the correct file. The title of the projection that you are currently modifying will be highlighted in bold with an * at the bottom of the screen.

14. To display the results of your projections, open the projections of interest and click "Results" to select your output. Please note, whichever projection you open first will display first in the results tables.

15. A "Configure" window will appear allowing you to choose the display format for the indicator chosen (e.g. table, line graph, etc.). Select the first and final years to match the years of interest in the projection. Only LiST interventions modeled by the user should contribute to the total(s) for

any deaths averted (with the exception of PMTCT, Cotrimoxazole, and ART from AIM). If that is not the case, then unintentional changes may have been made and should be corrected. In addition, the number of deaths averted in the first year of intervention program ("impact year") should be 0. Make any necessary corrections. Save and close the projection.

7.4.3   LiST input editors

7.4.3.1   LiST configuration

First year of intervention program   Display sensitivity bounds around results   Direct entry of stunting/wasting   Direct entry of fertility risks   Manage interventions

1. Select the first year of intervention program from the drop-down menu. This refers to the baseline year from which the impacts of coverage changes are calculated (i.e., for a program to introduce rotavirus vaccine starting in 2012, the first year of intervention program would be 2011). This is the first year for which LiST will show outputs for results related to "additional deaths prevented relative to impact year." Although Spectrum technically anchors a projection based on DemProj and AIM data from the year specified as the start year for the projection, selecting the first year of intervention program will allow you to narrow the LiST output of the projection.   Top

NOTE: To ensure that intervention coverage data for your baseline year is accurate, check the data sources for the country of your projection (go to "Results" - "Tools" - "Source Summary") to see whether a nationally representative household survey (DHS or MICS) was conducted recently preceding your baseline year. If not (i.e., baseline data is significantly out of date), and you are not able to replace this with your own data, please interpret your results with caution.

2. [Optional] You may select "Display sensitivity bounds around results" if you would like to display an upper and lower bound around your estimates of impact in LiST Results. This is done by using an upper and lower estimate of the effectiveness value of each intervention in LiST.   Top

3. [Optional] You may select "Direct entry of stunting" and/or "Direct entry of wasting" if you would like to directly enter stunting and/or wasting values yourself in Coverage. Select this option if you have country-specific stunting/wasting data and want to look at the impact of changing stunting/wasting distributions on mortality.

When direct entry of stunting/wasting is on, the user should enter data on stunting/wasting distributions in the "Stunting"/"Wasting" tab of the "Coverage" menu (these tabs will only be visible when "direct entry" is turned on). In this setting, LiST will not calculate stunting/wasting distributions from intervention coverage change. Instead, mortality impact comes from the directly entered stunting/wasting distributions. If an intervention has mortality impact only via the stunting/wasting pathway, the user will be unable to edit this intervention when direct entry is on (the intervention will be grayed out). The user will still be able to edit coverage of interventions that affect mortality through multiple pathways that include stunting/wasting. These interventions will continue to affect mortality via the other pathways. For example, when direct entry of stunting is on, zinc supplementation does not affect stunting distribution, but does still have an impact on diarrhea and pneumonia mortality.

If direct entry is on and user does not enter data on stunting/wasting distribution, the mortality impact of interventions affecting stunting/wasting will be underestimated.

If direct entry is off, LiST calculates stunting/wasting distribution based on the change in coverage of interventions affecting stunting/wasting.   Top

4. [Optional] You may select "Direct entry of fertility risks" if you would like to directly enter fertility risk values yourself on the Fertility Risk tab in Coverage. This will automatically be checked if the family planning module (FamPlan) is not selected.   Top

5. [Optional] Finally, if you would like to create a custom intervention not currently included in LiST, click on the "Manage interventions" button and follow the instructions provided in the "Manage interventions" box.   Top

7.4.3.2   Manage interventions

Create custom interventions   Link interventions   Export interventions

This menu (within the "LiST configuration" menu) allows users to create customized analyses that include features that are not part of the validated and standardized model. These include creating new interventions from scratch, allowing interventions to have non-standard effects, and copying custom interventions to other LiST projections. The results of any changes made in this menu are solely the responsibility of the user. The LiST team is responsible for the functionality but not the results themselves.

Create custom interventions

In this section, the users can create an intervention which is not part of the standard LiST package.

1. First enter the name of this intervention. It should not be the same as any existing intervention within Spectrum.

2. Select the type of intervention time period in which the intervention is to be delivered. Only one may be selected, even if the intervention actually crosses many periods.

    a. If the period/type is Vaccines, then the user must also select at least one specific cause of death which this intervention can affect. This will create the space to configure herd effects/indirect effects as well.

Once the intervention has been created, the user must also enter the coverage of the intervention in the main coverage tabs as well as the effectiveness of the intervention in the effectiveness tabs. Note that these custom interventions can only affect causes of death. They cannot affect intermediate outcomes such as breastfeeding, stunting, or wasting.
Top

Link interventions

The link feature creates a special link between any selected existing intervention(s) (not custom interventions) and all causes of death. It allows the user to specify effects that are not part of the standard LiST package. It does not modify the existing linkages. To use this feature, the user must simply check the On/Off box to identify which existing interventions need to be allowed to affect non-standard causes of death.

Once the intervention has been linked, the user needs to enter the effectiveness tab for the relevant cause of death. On that tab, select "Show all interventions options." The selected intervention will appear and the user can enter their individual effectiveness and affected fraction information. It will be saved when the projection is saved.

Export interventions

This feature allows the user to copy the information in a custom intervention into an already existing projection. This will copy selected custom interventions as well as any links created with the "Link interventions" feature. Identify the projections you would like to add this information into. Currently, effectiveness levels are being copied, but affected fractions are not.

7.4.3.3 Health status, mortality, and economic status

This editor grouping gives what could be termed the "baseline status" of a mother, neonate, or child born in the country or region you are analyzing. It provides specific information about nutritional deficiencies, nutritional status at birth, incidence of certain illnesses, stunting and wasting distributions, pathogen distributions, baseline mortality rates and proximate causes for death, abortion incidence, stillbirth rate, and household economic details.

1. Review the default values for all the indicators under each tab and these data can modified if more appropriate or updated data sources are available.

2. To change the data, click on that box to highlight and type to enter the data. If you have changed the base year away from the default, ensure that the values are appropriate for the year of interest.

3. Remember to enter a record of any changes you make to the data sources and assumptions. To document this, right click on the table and select "All sources" or "Data Source (row)".

7.4.3.3.1 Baseline child health status

Percent vitamin A deficient   Percent zinc deficient   Status at birth   Incidence of diarrhea   Incidence of severe diarrhea   Incidence of severe pneumonia   Incidence of bacterial meningitis

Percent vitamin A deficient

- **Definition:** Percent of the population with inadequate intake of vitamin A.

- **Default data source:** Beal T, Massiot E, Arsenault JE, Smith MR, Hijmans RJ. Global trends in dietary micronutrient supplies and estimated prevalence of inadequate intakes. PLoS One. 2017;12(4):1–20. http://dx.doi.org/10.1371/journal.pone.0175554

- **Notes:** The estimates were based on dietary intake, excluding impact of current coverage of interventions.

Percent zinc deficient

- **Definition:** Percent of the population with inadequate intake of zinc.

- **Default data source:** Beal T, Massiot E, Arsenault JE, Smith MR, Hijmans RJ. Global trends in dietary micronutrient supplies and estimated prevalence of inadequate intakes. PLoS One. 2017;12(4):1–20. http://dx.doi.org/10.1371/journal.pone.0175554

- **Notes:** The estimates were based on dietary intake, excluding impact of current coverage of interventions.

Top

Status at birth

- **Definition:** Percentage of children born in one of four categories: Pre-term and small for gestational age (SGA), pre-term and appropriate for gestational age (AGA), term and SGA, and term and AGA. SGA is defined as <10th percentile; pre-term is defined as <37 weeks.

- **Default data source:** Lee AC, Katz J, Blencowe H, et al. National and regional estimates of term and preterm babies born small for gestational age in 138 low-income and middle-income countries in 2010. *Lancet Global Health* 2013; 1(1): e26-36. http://www.ncbi.nlm.nih.gov/pubmed/25103583.

- **Notes:**

- **Effect size reference:** LiST Technical Note: Birth outcomes and stunting at age one month

Top

Incidence of diarrhea

- **Definition:** Number of episodes of diarrhea that would be observed per child-year.

- **Default data source:** Fischer Walker CL, Rudan I, Liu L, et al. Global burden of childhood pneumonia and diarrhoea. *The Lancet* 2013; 381(9875): 1405-16. http://www.ncbi.nlm.nih.gov/pubmed/23582727.

- **Notes:** The standard DHS estimates cannot be used as they are typically collected in the dry season. The values are regional values.

Top

Incidence of severe diarrhea

- **Definition:** Number of episodes of severe diarrhea that would be observed per child-year.

- **Default data source:** Fischer Walker CL, Rudan I, Liu L, et al. Global burden of childhood pneumonia and diarrhoea. *The Lancet* 2013; 381(9875): 1405-16. http://www.ncbi.nlm.nih.gov/pubmed/23582727.

- **Notes:** The standard DHS estimates cannot be used as they are typically collected in the dry season. The values are regional values.

Top

Incidence of severe pneumonia

- **Definition:** Number of episodes of severe pneumonia that would be observed per child-year.

- **Default data source:** Rudan I, O'Brien KL, Nair H, et al. Epidemiology and etiology of childhood pneumonia in 2010: Estimates of incidence, severe morbidity, mortality, underlying risk factors and causative pathogens for 192 countries. *Journal of Global Health* 2013; 3(1). http://www.ncbi.nlm.nih.gov/pubmed/23826505. (Online supplementary material.)

- **Notes:**

Top

Incidence of bacterial meningitis

- **Definition:** Number of episodes of bacterial meningitis that would be observed per child-year.

- **Default data source:** Calculated from the following sources:

Davis S, Feikin D, Johnson HL. The effect of Haemophilus influenzae type B and pneumococcal conjugate vaccines on childhood meningitis mortality: A systematic review. *BMC Public Health* 2013; 13(Suppl 3): S21. http://www.ncbi.nlm.nih.gov/pubmed/24564188.

See also the WHO online companion table referenced in the following articles: Watt JP, Wolfson LJ, O'Brien KL, et al. Burden of disease caused by Haemophilus influenzae type b in children younger than 5 years: Global estimates. *Lancet* 2009; 374(9693): 903-911. http://www.ncbi.nlm.nih.gov/pubmed/19748399.

O'Brien KL, Wolfson LJ, Watt JP, et al. Burden of disease caused by Streptococcus pneumoniae in children younger than 5 years: Global estimates. *Lancet* 2009; 374(9693): 893-902. http://www.ncbi.nlm.nih.gov/pubmed/19748398.

- **Notes:**

Top

7.4.3.3.2 Baseline maternal health status

Malaria intervention   Percent of women exposed to falciparum Percent vitamin A deficient Percent calcium deficient Percent folate insufficient Percent of pregnant women with anemia   Percent of non-pregnant women with anemia   Percent of anemia among pregnant women due to iron deficiency Percent of anemia among non-pregnant women due to iron deficiency   Percent of pregnant women with severe anemia   Prevalence of low BMI among WRA   Percent of pregnant women with active syphilis

Malaria intervention

- **Definition:** This will be checked by default if IPTp or sleeping under an insecticide treated bednet (ITN) is recommended by the national government during pregnancy.

- **Default data source:** Roll Back Malaria (2007). Malaria and children: Progress in intervention coverage. http://www.childinfo.org/files/malaria_and_children.pdf. WHO World Malaria Report 2016 - Annexes. http://www.who.int/malaria/publications/world-malaria-report-2016/WMR-2016-annexes.pdf

- **Notes:** By default, IPTp can only benefit populations where the government has recommended that IPTp be used. The user can check the box if they would like to see the benefit of IPTp in other populations.

Top

Percent of women exposed to falciparum

- **Definition:** Percent of women exposed to falciparum malaria during pregnancy.

- **Default data source:** Korenromp, E. Malaria Incidence Estimates At Country Level For The Year 2004. Proposed Estimates And Draft Report for the RBM Monitoring and Evaluation Reference Group & MERG Task Force on Malaria Morbidity. March 2005. http://www.who.int/malaria/publications/atoz/incidence_estimations2.pdf.

-
- **Notes:**

Top

Percent of vitamin A deficient

- **Definition:** Percent of women who are vitamin A deficient during pregnancy

- **Default data source:** Global prevalence of vitamin A deficiency in populations at risk 1995-2005; https://www.who.int/publications/i/item/9789241598019

- **Notes:** The estimates were based on low serum retinol level.

Top

Percent calcium deficient

- **Definition:** Percent of the population with inadequate intake of calcium.

- **Default data source:** Beal T, Massiot E, Arsenault JE, Smith MR, Hijmans RJ. Global trends in dietary micronutrient supplies and estimated prevalence of inadequate intakes. PLoS One. 2017;12(4):1–20. http://dx.doi.org/10.1371/journal.pone.0175554

- **Notes:** The estimates were based on dietary intake, excluding impact of current coverage of interventions.

Top

Percent folate insufficient

- **Definition:** Percent of the population with inadequate intake of folate.

- **Default data source:** Beal T, Massiot E, Arsenault JE, Smith MR, Hijmans RJ. Global trends in dietary micronutrient supplies and estimated prevalence of inadequate intakes. PLoS One. 2017;12(4):1–20. http://dx.doi.org/10.1371/journal.pone.0175554

- **Notes:** The estimates were based on dietary intake, excluding impact of current coverage of interventions.

Top

Percent of pregnant women with anemia

- **Definition:** Percent of pregnant women with hemoglobin levels < 110 g/L.

- **Default data source:** Stevens GA, Finucane MM, De-Regil LM, et al. Global, regional, and national trends in haemoglobin concentration and prevalence of total and severe anaemia in children and pregnant and non-pregnant women for 1995-2011: a systematic analysis of population-representative data. *Lancet Global Health* 2013; 1(1): e16-25. http://www.ncbi.nlm.nih.gov/pubmed/25103581. (Unpublished data from the authors.)

- **Notes:**

Top

Percent of anemia among pregnant women due to iron deficiency

- **Definition:** Among pregnant women with hemoglobin levels < 110 g/L, the percentage where anemia is amenable to iron supplementation.

- **Default data source:** Stevens GA, Finucane MM, De-Regil LM, et al. Global, regional, and national trends in haemoglobin concentration and prevalence of total and severe anaemia in children and pregnant and non-pregnant women for 1995-2011: a systematic analysis of population-representative data. *Lancet Global Health* 2013; 1(1): e16-25. http://www.ncbi.nlm.nih.gov/pubmed/25103581. (Unpublished data from the authors.)

- **Notes:**

Top

Percent of non-pregnant women with anemia

- **Definition:** Percent of non-pregnant women aged 15-49 with hemoglobin levels < 120 g/L.

- **Default data source:** Stevens GA, Finucane MM, De-Regil LM, et al. Global, regional, and national trends in haemoglobin concentration and prevalence of total and severe anaemia in children and pregnant and non-pregnant women for 1995-2011: a systematic analysis of population-representative data. *Lancet Global Health* 2013; 1(1): e16-25. http://www.ncbi.nlm.nih.gov/pubmed/25103581. (Unpublished data from the authors.)

- **Notes:**

Top

Percent of anemia among non-pregnant women due to iron deficiency

- **Definition:** Among non-pregnant women aged 15-49 with hemoglobin levels < 120 g/L, the percentage where anemia is amenable to iron supplementation.

- **Default data source:** Stevens GA, Finucane MM, De-Regil LM, et al. Global, regional, and national trends in haemoglobin concentration and prevalence of total and severe anaemia in children and pregnant and non-pregnant women for 1995-2011: a systematic analysis of

population-representative data *Lancet Global Health* 2013; 1(1): e16-25. http://www.ncbi.nlm.nih.gov/pubmed/25103581. (Unpublished data from the authors.)

- **Notes:**

Top

Percent of pregnant women with severe anemia

- **Definition:** Percent of pregnant women with hemoglobin levels < 50 g/L.

- **Default data source:** Stevens GA, Finucane MM, De-Regil LM, et al. Global, regional, and national trends in haemoglobin concentration and prevalence of total and severe anaemia in children and pregnant and non-pregnant women for 1995-2011: a systematic analysis of population-representative data *Lancet Global Health* 2013; 1(1): e16-25. http://www.ncbi.nlm.nih.gov/pubmed/25103581. (Unpublished data from the authors.)

- **Notes:** See the LiST Technical Note on "Anemia and Maternal Mortality in LiST" for details on how severe anemia relates to maternal mortality risk.

Top

Prevalence of low body mass index (BMI) among women of reproductive age (WRA)

- **Definition:** Percent of women aged 15-49 with BMI <18.5

- **Default data source:** Finucane MM, Stevens GA, Cowan MJ, Danaei G, Lin JK, Paciorek CJ, Singh GM, Gutierrez HR, Lu Y, Bahalim AN, et al. National, regional, and global trends in body-mass index since 1980: Systematic analysis of health examination surveys and epidemiological studies with 960 country-years and 9.1 million participants. Lancet. Elsevier Ltd; 2011;377:557–67. http://dx.doi.org/10.1016/S0140-6736(10)62037-5 (Unpublished data from the authors.)

- **Notes:**

Top

Percent of pregnant women with active syphilis

- **Definition:** Percent of pregnant women with active syphilis.

- **Default data source:** Newman L, Kamb M, Hawkes S, et al. (2013) Global Estimates of Syphilis in Pregnancy and Associated Adverse Outcomes: Analysis of Multinational Antenatal Surveillance Data. PLoS Med 10(2): e1001396.

- **Notes:**

Top

7.4.3.3.3 Nutritional status distributions

Stunting Distributions   Wasting Distributions

Stunting distributions

- **Definition:** Distribution of the percent of children falling into one of four Z-score categories for height for age: <-3Z (severe stunting), -3 to -2Z (moderate stunting), -2 to -1Z (mild stunting), and >-1Z (not stunted). Stunting reflects chronic undernutrition.

- **Default data source:** Data have been recalculated for consistency across countries, using DHS and MICS datasets. This also ensures that the values reflect the exact age groups of interest.

- **Notes:** Disaggregated data are not available for 0-1 and 1-5 months. As a proxy, the 0-6 month values are applied to both age groups.

Top

Wasting distributions

- **Definition:** Distribution of the percent of children falling into one of four Z-score categories for weight for height: <-3Z (severe wasting), -3 to -2Z (moderate wasting), -2 to -1Z (mild wasting), and >-1Z (not wasted). Wasting reflects acute undernutrition.

- **Default data source:** Data have been recalculated for consistency across countries, using DHS and MICS datasets. This also ensures that the values reflect the exact age groups of interest.

- **Notes:** Disaggregated data are not available for 0-1 and 1-5 months. As a proxy, the 0-6 month values are applied to both age groups.

Top

7.4.3.3.4 Pathogens

Diarrhea   Pneumonia   Meningitis

This tab of the editor contains data on pathogen distribution in the absence of effective interventions.

Diarrhea

- **Definition:** Proportion of incident cases of severe diarrhea categorized by the causal pathogen. Proportion of deaths due to diarrhea categorized by the causal pathogen. Both proportions assume prior to rotavirus vaccine introduction.

- **Default data source:**

- Rotavirus among all cases:
- Mohan, V. R., Karthikeyan, R., Babji, S., McGrath, M., Shrestha, S., Shrestha, J., Mdumah, E., Amour, C., Samie, A., Nyathi, E., Haque, R., Qureshi, S., Yori, P. P., Lima, A., Bodhidatta, L., Svensen, E., Bessong, P., Ahmed, T., Seidman, J. C., Zaidi, A., … Etiology, Risk Factors, and Interactions of Enteric Infections and Malnutrition and the Consequences for Child Health and Development (MAL-ED) Network Investigators (2017). Rotavirus Infection and Disease in a Multisite Birth Cohort: Results From the MAL-ED Study. The Journal of infectious diseases, 216(3), 305–316. https://doi.org/10.1093/infdis/jix199

- Rotavirus among severe and fatal cases:
- Fischer Walker CL, Rudan I, Liu L, et al. Global burden of childhood pneumonia and diarrhoea. *The Lancet* 2013; 381(9875): 1405-16. http://www.ncbi.nlm.nih.gov/pubmed/23582727.

- **Notes:** Pathogen B and Pathogen C serve as placeholders for future diarrhea analysis work.

Pneumonia

- **Definition:** Proportion of incident cases of severe pneumonia categorized by the causal pathogen. Proportion of deaths due to pneumonia categorized by the causal pathogen. Both proportions assume prior to Hib and pneumococcal vaccine introduction.

- **Default data source:**

- H. influenzae type b:
- Wahl, B., O'Brien, K. L., Greenbaum, A., Majumder, A., Liu, L., Chu, Y., Lukšić, I., Nair, H., McAllister, D. A., Campbell, H., Rudan, I., Black, R., & Knoll, M. D. (2018). Burden of Streptococcus pneumoniae and Haemophilus influenzae type b disease in children in the era of conjugate vaccines: global, regional, and national estimates for 2000-15. The Lancet. Global health, 6(7), e744–e757. https://doi.org/10.1016/S2214-109X(18)30247-X
- Please refer to the online supplementary material.

- S. pneumoniae, calculated from the following sources:

- All S. pneumoniae:
- Wahl, B., O'Brien, K. L., Greenbaum, A., Majumder, A., Liu, L., Chu, Y., Lukšić, I., Nair, H., McAllister, D. A., Campbell, H., Rudan, I., Black, R., & Knoll, M. D. (2018). Burden of Streptococcus pneumoniae and Haemophilus influenzae type b disease in children in the era of conjugate vaccines: global, regional, and national estimates for 2000-15. The Lancet. Global health, 6(7), e744–e757. https://doi.org/10.1016/S2214-109X(18)30247-X
- Please refer to the online supplementary material.

- Vaccine-type serotype by region:
- Johnson, H. L., Deloria-Knoll, M., Levine, O. S., Stoszek, S. K., Freimanis Hance, L., Reithinger, R., Muenz, L. R., & O'Brien, K. L. (2010). Systematic evaluation of serotypes causing invasive pneumococcal disease among children under five: the pneumococcal global serotype project. PLoS medicine, 7(10), e1000348. https://doi.org/10.1371/journal.pmed.1000348
- Please refer to the online supporting information.

- **Notes:**

Meningitis

- **Definition:** Proportion of incident cases of meningitis categorized by the causal pathogen. Proportion of deaths due to meningitis categorized by the causal pathogen. Both proportions assume prior to Hib and pneumococcal vaccine introduction.

- **Default data source:**
- H. influenzae type b:
- Wahl, B., O'Brien, K. L., Greenbaum, A., Majumder, A., Liu, L., Chu, Y., Lukšić, I., Nair, H., McAllister, D. A., Campbell, H., Rudan, I., Black, R., & Knoll, M. D. (2018). Burden of Streptococcus pneumoniae and Haemophilus influenzae type b disease in children in the era of conjugate

vaccines: global, regional, and national estimates for 2000-15. The Lancet. Global health, 6(7), e744–e757. https://doi.org/10.1016/S2214-109X(18)30247-X
- Country-specific proportions provided via direct communication with author.

- S. pneumoniae, calculated from the following sources:

- All S. pneumoniae:
- Wahl, B., O'Brien, K. L., Greenbaum, A., Majumder, A., Liu, L., Chu, Y., Lukšić, I., Nair, H., McAllister, D. A., Campbell, H., Rudan, I., Black, R., & Knoll, M. D. (2018). Burden of Streptococcus pneumoniae and Haemophilus influenzae type b disease in children in the era of conjugate vaccines: global, regional, and national estimates for 2000-15. The Lancet. Global health, 6(7), e744–e757. https://doi.org/10.1016/S2214-109X(18)30247-X
- Country-specific proportions provided via direct communication with author.

- Vaccine-type serotype by region:
- Johnson, H. L., Deloria-Knoll, M., Levine, O. S., Stoszek, S. K., Freimanis Hance, L., Reithinger, R., Muenz, L. R., & O'Brien, K. L. (2010). Systematic evaluation of serotypes causing invasive pneumococcal disease among children under five: the pneumococcal global serotype project. PLoS medicine, 7(10), e1000348. https://doi.org/10.1371/journal.pmed.1000348
- Please refer to the online supporting information.

- N. meningitidis, calculated from the following sources:

- All N. meningitidis:
- Wahl, B., O'Brien, K. L., Greenbaum, A., Majumder, A., Liu, L., Chu, Y., Lukšić, I., Nair, H., McAllister, D. A., Campbell, H., Rudan, I., Black, R., & Knoll, M. D. (2018). Burden of Streptococcus pneumoniae and Haemophilus influenzae type b disease in children in the era of conjugate vaccines: global, regional, and national estimates for 2000-15. The Lancet. Global health, 6(7), e744–e757. https://doi.org/10.1016/S2214-109X(18)30247-X
- Country-specific proportions provided via direct communication with author.

- Vaccine-type serotype:
- Trotter, C. L., Lingani, C., Fernandez, K., Cooper, L. V., Bita, A., Tevi-Benissan, C., Ronveaux, O., Préziosi, M. P., & Stuart, J. M. (2017). Impact of MenAfriVac in nine countries of the African meningitis belt, 2010-15: an analysis of surveillance data. The Lancet. Infectious diseases, 17(8), 867–872. https://doi.org/10.1016/S1473-3099(17)30301-8

- **Notes:**

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7.4.3.3.5 Baseline child mortality

Neonatal mortality rate   Infant mortality rate   Under-five mortality rate   Percent of child deaths by proximate cause

You may choose to review and leave the default values for baseline child mortality (neonatal mortality rate, infant mortality rate, and under-five mortality rate), or you may click anywhere in the table of interest to begin entering data. You may also review the distributions for child deaths by proximate cause (neonatal and post-neonatal), and adjust as appropriate.

Neonatal mortality rate

- **Definition:** Number of deaths during the neonatal period (first 28 completed days of life) per 1,000 live births.

- **Default data source:** Estimates developed by the UN Inter-Agency Group for Child Mortality Estimation (http://www.childmortality.org/).

- **Notes:** All values can be replaced with DHS/MICS or other estimates if they are more appropriate for the analysis that will be completed.

Top

Infant mortality rate

- **Definition:** Number of deaths of children under one year of age per 1,000 live births.

- **Default data source:** Estimates developed by the UN Inter-Agency Group for Child Mortality Estimation (http://www.childmortality.org/).

- **Notes:** All values can be replaced with DHS/MICS or other estimates if they are more appropriate for the analysis that will be completed.

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Under-five mortality rate

- **Definition:** Probability of a child born in a specific year or period dying before reaching the age of five, if subject to age-specific mortality rates of that period.

- **Default data source:** Estimates developed by the UN Inter-Agency Group for Child Mortality Estimation (http://www.childmortality.org/).

- **Notes:** All values can be replaced with DHS/MICS or other estimates if they are more appropriate for the analysis that will be completed.

Top

Percent of child deaths by proximate cause

- **Definition:** The proportion of under-five deaths due to one of eight neonatal causes (diarrhea, sepsis, pneumonia, asphyxia, prematurity, tetanus, congenital anomalies, and other) and nine post-neonatal causes (diarrhea, pneumonia, meningitis, measles, malaria, pertussis, AIDS, injury, and other).

- **Default data source:** WHO estimates for years 2000-2017.
  https://www.who.int/data/gho/data/themes/mortality-and-global-health-estimates

  Liu L, Oza S, Hogan D, et al. Global, regional, and national causes of under-5 mortality in 2000-15: an updated systematic analysis with implications for the Sustainable Development Goals. *Lancet* 2016. https://www.ncbi.nlm.nih.gov/pubmed/27839855.

- **Notes:** All causes of death can be modified in this table except the HIV deaths, which are brought in from the AIDS Impact Module (AIM). To modify these, you will need to open and edit within AIM. Also note that the sum of these causes should equal 100%.

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7.4.3.3.6 Baseline maternal mortality

Maternal mortality ratio   Percent of maternal deaths by proximate cause

You may choose to review and leave the default values for the maternal mortality ratio and the percent of maternal deaths by proximate cause, or you may click anywhere in the editor screen to begin entering data.

Maternal mortality ratio

- **Definition:** The ratio of the number of maternal deaths per 100,000 live births. A maternal death is the death of a woman while pregnant or within 42 days of termination of pregnancy, irrespective of the duration and site of the pregnancy, from any cause related to or aggravated by the pregnancy or its management but not from accidental or incidental causes.

- **Default data source:** WHO, "Trends in Maternal Mortality: 2000 to 2017." https://www.who.int/publications/i/item/9789241516488

- **Notes:** All values can be replaced with DHS/MICS or other estimates if they are more appropriate for the analysis that needs to be completed.

  LiST Technical Note: Understanding how FamPlan calculates the numbers of abortions and their impact on the maternal mortality ratio (MMR) in LiST

Top

Percent of maternal deaths by proximate cause

- **Definition:** The proportion of maternal deaths due to one of nine causes (antepartum hemorrhage, intrapartum hemorrhage, postpartum hemorrhage, hypertensive disorders, sepsis, abortion, embolism, other direct causes, and indirect causes).

- **Default data source:** Say L, Chou D, Gemmill A, et al. Global causes of maternal death: A WHO systematic analysis. *Lancet Global Health* 2014; 2(6): e323-33. http://www.ncbi.nlm.nih.gov/pubmed/25103301. Data are from unpublished tables associated with this article.

- **Notes:**

Top

7.4.3.3.7 Abortion

Percent of pregnancies ending with spontaneous abortion   Abortion incidence ratio

Review the default percent of pregnancies ending with spontaneous abortion and the abortion incidence ratio, and make any changes necessary. If you have FamPlan active, you may click on "Calculate abortion ratio based on FamPlan outputs" if you would like the abortion ratio to be calculated from FamPlan inputs such as method mix and proximate determinants of fertility.

Percent of pregnancies ending with spontaneous abortion

- **Definition:** The spontaneous end of a pregnancy at a stage where the embryo or fetus is incapable of surviving independently, generally defined in humans as prior to 20 weeks of gestation. Spontaneous abortions are not easily measured and are thus assumed to average 13% of pregnancies in all countries.

- **Default data source:** Gold, R. Abortion and Women's Health: A Turning Point for America? New York and Washington, DC: The Alan Guttmacher Institute; 1990.

- **Notes:**

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Abortion incidence ratio

- **Definition:** The abortion incidence is expressed as a ratio of abortions per 100 live births.

- **Default data source:** Sedgh G, Bearak J, Singh S, et al. Abortion incidence between 1990 and 2014: global, regional, and subregional levels and trends. Lancet 2016; 388: 16-22. http://www.ncbi.nlm.nih.gov/pubmed/27179755. (Unpublished calculations based on abortion incidence rates in paper.)

- **Notes:** Values are by subregion.

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7.4.3.3.8 Stillbirth

Stillbirth rate   Percent of stillbirths by proximate cause

You may choose to review and leave the default values for the stillbirth rate and the percent of stillbirths by proximate cause, or you may click anywhere in the editor screen to begin entering data.

Stillbirth rate

- **Definition:** The number of stillbirths per 1,000 births. For international comparisons, WHO considers stillbirths as pregnancy losses at or after 28 weeks of pregnancy, or a birth weight of at least 1,000 grams.

- **Default data source:** United Nations Inter-agency Group for Child Mortality Estimation (UN IGME) Stillbirth Summary

- **Notes:**

Top

Percent of stillbirths by proximate cause

- **Definition:** Stillbirths are not categorized by cause due to a lack of data. Rather, they are categorized by time period, either antepartum (prior to delivery) and intrapartum (during delivery).

- **Default data source:** Unpublished data from United Nations Inter-agency Group for Child Mortality Estimation (UN IGME), 'A Neglected Tragedy: The global burden of stillbirths', United Nations Children's Fund, New York, 2020.

- **Notes:**

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7.4.3.3.9 Household status

[Poverty/food security](#)   [Average household size](#)

Poverty/food security

- **Definition:** The percent of population who experience moderate or severe food insecurity. Or the percent of the population living on less than $1.90/day according to purchasing power parity (adjusted to 2011 international dollars).

- **Default data source:** Food insecurity experience scale (FIES): Suite of Food Security Indicators Available from: https://www.fao.org/faostat/en/#data/FS. For more information on FIES: Ballard TJ, Kepple AW, Cafiero C. The food insecurity experience scale: developing a global standard for monitoring hunger worldwide. Technical Paper. Rome: FAO; 2013.

- World Bank, Development Research Group. Poverty headcount ratio at $1.90 a day (PPP) (% of population). http://data.worldbank.org/indicator/SI.POV.DDAY.

  Where national-level rates were not available, estimates by World Bank [country income level group](#) were used.

  World Bank, Development Research Group. Data are based on primary household survey data obtained from government statistical agencies and World Bank country departments. Data for high-income economies are from the Luxembourg Income Study database. For more information and methodology, please see PovcalNet (http://iresearch.worldbank.org/PovcalNet/index.htm).

- **Notes:** When FIES data are unavailable, the percentage of population living on <$1.9/day is used. See [technical note](#)

Top

Average household size

- **Definition:** The average number of people living in a household.

- **Default data source:** Data are drawn from DHS, MICS, and other nationally representative household surveys.

- **Notes:** This is only used to estimate households in need for costing purposes.

Top

7.4.3.3.10 Economic Status

[First and last ages at work](#) [GNI per capita](#) [Labor force participation rate](#) [Labor share of income](#)

First and last ages at work

- **Definition:** The age entering the labor market; The age to retire or exist the labor market.

- **Note**: Since additional wage earnings will accrue only once for each child as the birth cohort enters the labor market. the recommended average working years is 44, starting at the age of 16 years and retiring at the age of 60 years.

- **Default data source:** Wong B, Radin M. Benefit-Cost Analysis of a Package of Early Childhood Interventions to Improve Nutrition in Haiti. J Benefit Cost Anal. 2019;10(Suppl 1):154-184. doi: 10.1017/bca.2019.1. Epub 2019 Feb 28. PMID: 32968617; PMCID: PMC7473066. https://pubmed.ncbi.nlm.nih.gov/32968617/

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GNI per capita

- **Definition:** gross national income, converted to U.S. dollars using the World Bank Atlas method, divided by the midyear population.

- **Note**: Based on the user's selection for first and last ages at work, GNI per capita will display to the year when all the birth cohorts exists the labor market.
- All the retrospective GNI per capita data (2000-2019) were retrieved from World Bank database. The future GNI per capita are projected based on IIASA-SSP database. IIASA-SSP projects annual growth rates using five different models and reports the growth rates for every five years. The average of the projected annual growth rates across five models were applied to each country for the specific five-year period. We included the projected annual GNI per capita growth rates from 2020 to 2080. For years beyond 2080, GNI per capita will be projected using the annual growth rates for 2075-2080. Users can use other estimates if they are more appropriate for the analysis that will be completed.
- Future wage is estimated based on the following formula: Wage=GNI per capita * labor share of income / labor force participation rate
- When user estimates the present value of additional lifetime earnings obtained by the birth cohort, user can choose to apply different discount rates: 3%, 5%, or 10%.

- **Default data source**: World Bank https://data.worldbank.org/
- IIASA-SSP database https://tntcat.iiasa.ac.at/SspDb/dsd?Action=htmlpage&page=about Accessed March 2021
- Claxton K, Asaria M, Chansa C, Jamison J, Lomas J, Ochalek J, Paulden M. Accounting for Timing when   Assessing Health-Related Policies. J Benefit Cost Anal. 2019 Jan 26;10(Suppl 1):73-105. doi: 10.1017/bca.2018.29. PMID: 33282628; PMCID: PMC7691758. https://pubmed.ncbi.nlm.nih.gov/33282628/

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Labor force participation rate

- **Definition:** proportion of the total population that is working/economically active.

- **Note**: The proportion of the populations ages 15 and older that is economically active and the proportion of population ages 0-14 years old were retrieved from World Bank database. And we used the two indicators to calculation country-specific labor force participation rate. Users can use other estimates if they are more appropriate for the analysis that will be completed.

- **Default data source**: World Bank https://data.worldbank.org/

Labor share of income

- **Definition**: the part of national income allocated to wages

- **Note**: the default labor share of income is 50%. Users can use other estimates if they are more appropriate for the analysis that will be completed.

- **Default data source**: Wong B, Radin M. Benefit-Cost Analysis of a Package of Early Childhood Interventions to Improve Nutrition in Haiti. J Benefit Cost Anal. 2019;10(Suppl 1):154-184. doi: 10.1017/bca.2019.1. Epub 2019 Feb 28. PMID: 32968617; PMCID: PMC7473066. https://pubmed.ncbi.nlm.nih.gov/32968617/

7.4.3.4   Coverage

This section describes the types of interventions which are available within *LiST* for modification. Each type is characterized by either the time in which the intervention is delivered (i.e., during pregnancy) or by the mode of activity (i.e., vaccines or curative). All items which fall under the categories of breastfeeding, preventive, vaccines, and curative occur after birth. Select any one of the types/time periods for more information on all interventions which are included.

To enter coverage data:

1. Click on the tab for the editor screen that you wish to work in, to bring that screen to the forefront.

2. Review the default values listed for each child health intervention for all years displayed.

3. Edit the coverage targets for future years past the first year of intervention manually if you have data you feel is more accurate than what is listed. *If you would like to make this first projection a "do nothing" scenario (or a theoretical counterfactual for your intended coverage changes), where the intervention coverage is by default held constant from the first year of intervention, do not change the default values after the first year of intervention. Click "Ok" and save the projection through the "Home" tab of the Spectrum menu. Then, proceed to reviewing effectiveness values.*

4. Edit the coverage values from the first year of intervention to the target year. **By changing the target, you will be able to project the impact upon child survival in your country.** Most often, users set a target for the final year of the projection (2015 in the case of the MDGs) and interpolate between the base year and the target year.

5. An easy way to change this coverage is to set the coverage in the target year and highlight from the first year of intervention to the target year. Then right click and scroll to "interpolate". There are four different interpolate options. Choose the one that best suits your data. Use the duplicate function if you would like several adjoining data boxes in a row or column to have the same value.

7.4.3.4.1 Periconceptual

Contraceptive use

- **Definition:** Coverage and effectiveness of Family Planning interventions are specified in the FamPlan module.

Top

Periconceptual folic acid

- **Definition:** Percent of women 15-49 that have appropriate food fortification (0.4 mg folic acid per day) around the time of pregnancy.

- **Default data source:** Coverage data for this indicator are calculated from the Food Fortification Initiative. Using fortification standard and daily food intake, we estimate the daily potential folic acid contribution from fortification. Any contribution beyond 100% is capped. To estimate the overall folic acid fortification coverage, we also adjust for quality and compliance using percent of food industrially processed and percent of food fortified. For more detail see the paper.

- **Notes:** This is not the same indicator as iron/folate supplementation during pregnancy.

- **Effect size reference:** Keats EC, Neufeld LM, Garrett GS, Mbuya MNN, Bhutta ZA. Improved micronutrient status and health outcomes in low- and middle-income countries following large-scale fortification: evidence from a systematic review and meta-analysis. Am J Clin Nutr. 2019;109(6):1696-1708. doi:10.1093/ajcn/nqz023. https://pubmed.ncbi.nlm.nih.gov/30997493/

  Imdad A, Yakoob MY, Bhutta ZA. The effect of folic acid, protein energy and multiple micronutrient supplements in pregnancy on stillbirths. *BMC Public Health* 2011; 11(Suppl 3): S4. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3231910/.

  Li B, Zhang X, Peng X, Zhang S, Wang X, Zhu C. Folic Acid and Risk of Preterm Birth: A Meta-Analysis. Front Neurosci. 2019 Nov 28;13:1284. doi: 10.3389/fnins.2019.01284. PMID: 31849592; PMCID: PMC6892975. https://pubmed.ncbi.nlm.nih.gov/31849592/

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Iron fortification

- **Definition:** Percent of women 15-49 that have appropriate food fortification (18 mg iron per day) around the time of pregnancy.

- **Default data source:** Coverage data for this indicator are calculated from the Food Fortification Initiative. Using fortification standard and daily food intake, we estimate the daily potential iron contribution from fortification. Any contribution beyond 100% is capped. To estimate the overall

iron fortification coverage, we also adjust for quality and compliance using percent of food industrially processed and percent of food fortified. For more detail see the paper.

- **Notes:** This is not the same indicator as iron supplementation during pregnancy.

- **Effect size reference:** Keats EC, Neufeld LM, Garrett GS, Mbuya MNN, Bhutta ZA. Improved micronutrient status and health outcomes in low- and middle-income countries following large-scale fortification: evidence from a systematic review and meta-analysis. Am J Clin Nutr. 2019;109(6):1696-1708. doi:10.1093/ajcn/nqz023. https://pubmed.ncbi.nlm.nih.gov/30997493/

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Safe abortion services

- **Definition:** Among women who get an abortion, the percent who get a safe abortion (defined as via D&C, vacuum aspiration, or medical abortion).

- **Default data source:** Sedgh G, Singh S, Shah IH, et al. Induced abortion: Incidence and trends worldwide from 1995 to 2008. *Lancet* 2012; 379(9816): 625-32. http://www.ncbi.nlm.nih.gov/pubmed/22264435.

- **Notes:** Country-specific estimates are not available. Regional data are being used.

- **Effect size reference:** Pollard SL, Mathai M, Walker N. Estimating the impact of interventions on cause-specific maternal mortality: A Delphi approach. *BMC Public Health* 2013, 13(Suppl 3): S12. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3847442/.

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Post-abortion case management

- **Definition:** Percent of women who have had an abortion who get the appropriate post-abortion case management at a Basic Emergency Obstetric Care (BEmOC) level.

- **Default data source:** Coverage data for this indicator are not typically available. Currently set at 0 for baseline; user should enter local data if possible and available.

- **Notes:**

- **Effect size reference:** Pollard SL, Mathai M, Walker N. Estimating the impact of interventions on cause-specific maternal mortality: A Delphi approach. *BMC Public Health* 2013, 13(Suppl 3): S12. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3847442/.

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Ectopic pregnancy case management

- **Definition:** Percent of women with an ectopic pregnancy who receive case management at a Basic Emergency Obstetric Care (BEmOC) level.

- **Default data source:** Coverage data for this indicator are not typically available. Currently set at 0 for baseline; user should enter local data if possible and available.

- **Notes:**

- **Effect size reference:** Pollard SL, Mathai M, Walker N. Estimating the impact of interventions on cause-specific maternal mortality: A Delphi approach. *BMC Public Health* 2013, 13(Suppl 3): S12. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3847442/.

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7.4.3.4.2 Pregnancy

Antenatal care   TT - tetanus toxoid vaccination   Prevention of malaria in pregnancy   Syphilis detection and treatment   Calcium supplementation   Low-dose aspirin   Progesterone for at risk births   Multiple micronutrient supplementation   Iron supplementation   Balanced energy-protein supplementation   Hypertensive disorders case management   Diabetes case management   Malaria case management   FGR-fetal growth restriction detection and management   PMTCT - Prevention of mother to child transmission of HIV

Antenatal care (1+ visit)

- **Definition:** Percent of women who attend one or more antenatal care visits delivered by skilled provider during their pregnancy (ANC 1+).

- **Default data source:** Coverage data for this indicator are drawn from DHS, MICS, and other nationally representative household surveys.

- **Notes:** This has no direct impact and is not currently displayed in the LiST editor. It is used as a component in the formulas used to determine the coverage of certain interventions delivered as a part of ANC. For details on the calculation of coverage of antenatal care interventions in LiST, please see LiST Technical Note

Antenatal care (4+ visits)

- **Definition:** Percent of women who attend four or more antenatal care visits delivered by any provider during their pregnancy (ANC 4+).

- **Default data source:** Coverage data for this indicator are drawn from DHS, MICS, and other nationally representative household surveys.

- **Notes:** This has no direct impact and is not currently displayed in the LiST editor. It is used as a component in the formulas used to determine the coverage of certain interventions delivered as a part of ANC. For details on the calculation of coverage of antenatal care interventions in LiST, please see LiST Technical Note

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TT - tetanus toxoid vaccination

- **Definition:** Percent of neonates who are protected at birth (PAB) from tetanus infection. PAB is defined as the percent of women who received two doses of tetanus toxoid during this pregnancy or ever: Received at least 2 doses, the last within 3 years; received at least three doses, the last within 5 years; received at least 4 doses, the last within 10 years; or received at least five doses during lifetime. Also known as TT2+.

- **Default data source:** WHO/UNICEF. Immunization surveillance, assessment, and monitoring. "Protected at birth" indicator (http://www.who.int/immunization/monitoring_surveillance/data/en/).

- **Notes:** Default data can be replaced with data from DHS/MICS or other sources as appropriate.

- **Effect size reference:** Blencowe H, Lawn J, Vandelaer J, et al. Tetanus toxoid immunization to reduce mortality from neonatal tetanus. *International Journal of Epidemiology* 2010; 39(Suppl 1): i102-i109. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2845866/.

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Prevention of malaria in pregnancy

- **Definition:** Percent of pregnant women receiving 2+ doses of Sp/Fansidar or sleeping under a long lasting insecticide treated net during pregnancy.

- **Default data source:** Coverage data for this indicator are drawn from DHS, MICS, and other nationally representative household surveys. This also includes Malaria Indicator Surveys.

- **Notes:** By default, this indicator can only be modified if the national government recommends malaria intervention. This can be changed on the "Baseline child health status" tab of the "Health status, mortality, and economic status" menu.

The effect is only applied to the first and second pregnancies among women who are exposed to malaria.

Coverage is calculated as the greater of either a) IPTp coverage or b) coverage of ITN-use among pregnant women based on household survey data.

- **Effect size reference:** Eisele TP, Larsen D, Steketee RW. Protective efficacy of interventions for preventing malaria mortality in children in Plasmodium falciparum endemic areas. *International Journal of Epidemiology* 2010; 39(Suppl 1): i88-i10. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2845865/. (The pooled effect size for IPTp or ITN usage is applied for IPTp and/or ITN use due to similar causal pathways for preventing maternal anemia and lack of evidence of a synergistic effect.)

Pollard SL, Mathai M, Walker N. Estimating the impact of interventions on cause-specific maternal mortality: A Delphi approach. *BMC Public Health* 2013; 13(Suppl 3): S12. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3847442/. (The effect size for either IPTp or ITN usage is applied for IPTp and/or ITN use due to similar causal pathways for preventing maternal anemia and lack of evidence of a synergistic effect.)

Gamble CL, Ekwaru JP, ter Kuile FO. Insecticide-treated nets for preventing malaria in pregnancy.

Cochrane Database of Systematic Reviews 2006, Issue 2. Art. No.: CD003755. DOI: 10.1002/14651858.CD003755.pub2. (The effect size for ITN usage is applied as a proxy for IPTp and/or ITN use due to similar causal pathways for preventing stillbirth and lack of evidence of a synergistic effect.)

Radeva-Petrova D, Kayentao K, Ter Kuile FO, et al. Drugs for preventing malaria in pregnant women in endemic areas: Any drug regimen versus placebo or no treatment. *Cochrane Database Syst Rev* 2014. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4498495/. (The effect size for IPTp usage is applied as a proxy for IPTp and/or ITN use due to similar causal pathways for preventing maternal anemia and lack of evidence of a synergistic effect.)

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Syphilis detection and treatment

- **Definition:** Percent of pregnant women tested for syphilis and given treatment if needed.

- **Default data source:** Coverage data for this indicator are not typically available. As a proxy, coverage is calculated from utilization data from household survey and readiness data from healthy facility survey. For details on this calculation, please see the LiST Technical Note

- **Notes:** The default coverage=antenatal care (at least 1 visit) * quality. You can either change utilization (ANC1) or quality to alter coverage. Or you can select coverage at the top box and then change coverage directly

- **Effect size reference:** Blencowe H, Cousens S, Kamb M, et al. Lives Saved Tool supplement detection and treatment of syphilis in pregnancy to reduce syphilis related stillbirths and neonatal mortality. *BMC Public Health* 2011; 11(Suppl 3): S9. http://www.ncbi.nlm.nih.gov/pubmed/21501460.

- Wan Z, Zhang H, Xu H, Hu Y, Tan C, Tao Y. Maternal syphilis treatment and pregnancy outcomes: a retrospective study in Jiangxi Province, China. BMC Pregnancy Childbirth. 2020 Oct 27;20(1):648. doi: 10.1186/s12884-020-03314-y. PMID: 33109116; PMCID: PMC7590689. https://pubmed.ncbi.nlm.nih.gov/33109116/

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Calcium supplementation

- **Definition:** Percent of pregnant women taking 1g of calcium daily.

- **Default data source:** Coverage data for this indicator are not typically available. Currently set at 0 for baseline; user should enter local data if possible and available.

- **Notes:** The effect size is applied to the percentage of the population who are calcium deficient.This is a country-specific value found in the "Health status, mortality and economic status" tab under "Baseline maternal health status."

- **Effect size reference:** Hofmeyr GJ, Lawrie TA, Atallah ÁN, Torloni MR. Calcium supplementation during pregnancy for preventing hypertensive disorders and related problems. Cochrane Database Syst Rev. 2018 Oct 1;10(10):CD001059. doi: 10.1002/14651858.CD001059.pub5. PMID: 30277579; PMCID: PMC6517256. https://pubmed.ncbi.nlm.nih.gov/30277579/

Low-dose aspirin

- **Definition:** Percent of pregnant women at risk of preterm births who receive low-dose aspirin

- **Default data source:** Coverage data for this indicator are not typically available; it is set to 0 by default

- **Notes:**

- **Effect size reference:** Hoffman MK, Goudar SS, Kodkany BS, et al. Low-dose aspirin for the prevention of preterm delivery in nulliparous women with a singleton pregnancy (ASPIRIN): a randomised, double-blind, placebo-controlled trial. Lancet 2020; 395(10220): 285-93.

Progesterone for at risk births

- **Definition:** Percent of pregnant women at risk of preterm births who receive progesterone

- **Default data source:** Coverage data for this indicator are not typically available; it is set to 0 by default

- **Notes:**

- **Effect size reference:** Epppic Group. Evaluating Progestogens for Preventing Preterm birth International Collaborative (EPPPIC): meta-analysis of individual participant data from randomised controlled trials. Lancet 2021; 397(10280): 1183-94.

Multiple micronutrient supplementation

- **Definition:** Percent of pregnant women taking a multiple micronutrient supplement daily. A multiple micronutrient supplement is defined as a supplement containing at least iron, folate, and additional vitamins/minerals.

- **Default data source:** Coverage data for this indicator are not typically available. Currently set at 0 for baseline; user should enter local data if possible and available.

- **Notes:** The sum of multiple micronutrient supplementation and iron supplementation cannot be greater than 100%.

- **Effect size reference:** Smith ER, Shankar AH, Wu LSF, et al. Modifiers of the effect of maternal multiple micronutrient supplementation on stillbirth, birth outcomes, and infant mortality: a meta-analysis of individual patient data from 17 randomised trials in low-income and middle-income countries. Lancet Global Health 2017; 5(11): e1090-e1100.
http://www.thelancet.com/journals/langlo/article/PIIS2214-109X(17)30371-6/fulltext

  Oh C, Keats EC, Bhutta ZA. Vitamin and Mineral Supplementation During Pregnancy on Maternal, Birth, Child Health and Development Outcomes in Low- and Middle-Income Countries: A Systematic Review and Meta-Analysis. Nutrients. 2020 Feb 14;12(2):491. doi: 10.3390/nu12020491. PMID: 32075071; PMCID: PMC7071347. https://pubmed.ncbi.nlm.nih.gov/32075071/

Iron supplementation

- **Definition:** Percent of pregnant women taking an iron supplement daily, for at least 90 days.

- **Default data source:** Coverage data for this indicator are drawn from DHS, MICS, and other nationally representative household surveys.

- **Notes:** The sum of iron supplementation and multiple micronutrient supplementation cannot be greater than 100%.

- **Effect size reference:** Pena-Rosas JP, De-Regil LM, Garcia-Casal MN, et al. Daily oral iron supplementation during pregnancy. Cochrane Database Syst Rev 2015. http://www.ncbi.nlm.nih.gov/pubmed/26198451

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Balanced energy-protein supplementation

- **Definition:** Percent of pregnant women who are food insecure who receive balanced energy-protein (BEP) supplementation.

- **Default data source:** Coverage data for this indicator are not typically available. Currently set at 0 for baseline; user should enter local data if possible and available.

- **Notes:** The effect size is applied to the prevalence of body mass index (BMI) <18.5 among women of reproductive age (15-49 years), used as a proxy for food insecurity (the "Baseline Maternal Health Status" tab of the "Health status, mortality, and economic status" menu).

- **Effect size reference:** Lassi ZS, Padhani ZA, Rabbani A, Rind F, Salam RA, Das JK, Bhutta ZA. Impact of Dietary Interventions during Pregnancy on Maternal, Neonatal, and Child Outcomes in Low- and Middle-Income Countries. Nutrients. 2020; 12(2):531. https://doi.org/10.3390/nu12020531

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Hypertensive disorders case management

- **Definition:** Percent of women receiving detection and appropriate management of moderate to severe hypertension during pregnancy.

- **Default data source:** Coverage data for this indicator are not typically available. As a proxy, coverage is calculated from utilization data from household survey and readiness data from healthy facility survey. For details on this calculation, please see the LiST Technical Note

- **Notes:** The default coverage=antenatal care (at least 4 visit) * quality. You can either change utilization (ANC4) or quality to alter coverage. Or you can select coverage at the top box and then change coverage directly

- **Effect size reference:** Pollard SL, Mathai M, Walker N. Estimating the impact of interventions on cause-specific maternal mortality: A Delphi approach. *BMC Public Health* 2013; 13(Suppl 3): S12. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3847442/.

  Jabeen M, Yakoob MY, Imdad A, et al. Impact of interventions to prevent and manage preeclampsia and eclampsia on stillbirths. BMC Public Health 2011; 11(Suppl 3): S6. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3231912/

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Diabetes case management

- **Definition:** Percent of pregnant women screened for diabetes and managed appropriately, if needed.

- **Default data source:** Coverage data for this indicator are not typically available. As a proxy, coverage is calculated from utilization data from household survey and readiness data from healthy facility survey. For details on this calculation, please see the LiST Technical Note

- **Notes:** This currently only impacts stillbirths. The default coverage=antenatal care (at least 4 visit) * quality. You can either change utilization (ANC4) or quality to alter coverage. Or you can select coverage at the top box and then change coverage directly

- **Effect size reference:** Syed M, Javed H, Yakoob MY, et al. Effect of screening and management of diabetes during pregnancy on stillbirths. *BMC Public Health* 2011; 11(Suppl 3): S2. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3231893/.

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Malaria case management

- **Definition:** Percent of pregnant women experiencing malaria that are appropriately managed.

- **Default data source:** Coverage data for this indicator are not typically available. As a proxy, coverage is calculated from utilization data from household survey and readiness data from healthy facility survey. For details on this calculation, please see the LiST Technical Note

- **Notes:** The intervention covers the entire period between conception and six weeks after delivery. The default coverage=antenatal care (at least 4 visit) * quality. You can either change utilization (ANC4) or quality to alter coverage. Or you can select coverage at the top box and then change coverage directly

- **Effect size reference:** Pollard SL, Mathai M, Walker N. Estimating the impact of interventions on cause-specific maternal mortality: A Delphi approach. *BMC Public Health* 2013; 13(Suppl 3): S12. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3847442/.

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FGR - fetal growth restriction detection and management

- **Definition:** Percent of pregnancies screened for fetal growth restriction (including BMI, fundal height, ultrasound, and/or Doppler) and managed with appropriate obstetric intervention, including early delivery, if needed.

- **Default data source:** Coverage data for this indicator are not typically available. Currently set at 0 for baseline; user should enter local data if possible and available.

- **Notes:** Based on a review by Imdad and colleagues, the impact of detection and management of fetal growth restriction was added to LiST. (Imdad A, Yakoob MY, Siddiqui S, et al. Screening and triage of intrauterine growth restriction (IUGR) in general population and high risk pregnancies: a systematic review with a focus on reduction of IUGR related stillbirths *BMC Public Health* 2011, 11(Suppl 3): S1. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3231882/.) The review found that proper detection and management of IUGR (fetal growth restriction) could reduce stillbirths by 20%. However, this analysis depends on proper management, often including induced labor and Cesarean sections, that may not be available in low-resource settings. In addition, by producing earlier births, management does reduce the stillbirths, but the child of the resulting birth may be premature and appropriate management of premature babies, especially those very premature, may not be available. The users who choose to scale up FGR should be aware of these difficulties and will need to specify the effectiveness of the intervention.

- **Effect size reference:** The effect size is currently set to 0 (see above); use the "Effectiveness" menu to modify if necessary.

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PMTCT - Prevention of mother to child transmission of HIV

- **Definition:** Coverage and effectiveness of PMTCT interventions are specified in the AIM module.

- **Default data source:**

- **Notes:**

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7.4.3.4.3 Childbirth

Health facility delivery   Clean birth environment   Immediate drying and additional stimulation
Thermal protection Delayed cord clamping Clean cord care   MgSO4 for eclampsia   Antibiotics for
preterm or prolonged PROM   Antibiotics for maternal sepsis   Assigned vaginal delivery   Neonatal
resuscitation   Uterotonics for postpartum hemorrhage   Manual removal of placenta Removal of
retained products of conception Induction of labor for pregnancis lasting 41+ weeks   Antenatal
corticosteroids for preterm labor   Cesarean delivery Blood transfusion Case management of premature
babies KMC - Kangaroo Mother Care   Full supportive care for prematurity iKMC

Within the "Childbirth" tab, LiST will automatically calculate the distributions of delivery levels and coverage levels of childbirth interventions, unless you uncheck "Allow LiST to calculate place and level of delivery" to manually change level and place of delivery or uncheck "Allow LiST to calculate intervention coverages" to manually enter coverage for childbirth interventions.

Please note that to manually edit coverage of childbirth interventions you must (after unchecking "Allow LiST to calculate intervention coverages") specify which of the childbirth interventions are available at which level of care, before proceeding to the tab for the each delivery level to enter coverage values. Coverage for each intervention can be entered as either the percentage of all deliveries, or as the percentage of that delivery level specifically. If you need to return the box where you specify the availability of childbirth interventions, you must recheck and then uncheck the "Allow LiST to calculate intervention coverages" box. This will require you to reenter all changes made.

Health facility delivery

- **Definition:** Percent of children born in a health facility.

- **Default data source:** Coverage data for this indicator are drawn from DHS, MICS, and other nationally representative household surveys.

- **Notes:** This intervention has no effect alone. It is used to calculate the estimated coverage of all childbirth care interventions in combination with readiness data from healthy facility survey.

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Clean Birth Environment

- **Definition:** Percent of deliveries with clean/sterile environment from kit or infection prevention measures (i.e. handwashing, clean perineum, clean surface), including use of clean instrument to cut and tie the umbilical cord

- **Default data source:** Coverage data are calculated from readiness and utilization data. For details on this calculation, please see the LiST Technical Note

- The default coverage=health facility delivery * quality. You can either change utilization (health facility delivery) or quality to alter coverage. Or you can select coverage at the top box and then change coverage directly

- **Notes:** The assumptions should be adjusted based on local knowledge and data. One potential choice is to use a clean delivery kit in the home for unassisted deliveries as an indicator of clean birth practices.

- **Effect size reference:** Blencowe H, Cousens S, Mullany LC, et al. Clean birth and postnatal care practices to reduce neonatal deaths from sepsis and tetanus: A systematic review and Delphi estimation of mortality effect. *BMC Public Health* 2011; 11(Suppl 3): S11. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3231884/.

  Pollard SL, Mathai M, Walker N. Estimating the impact of interventions on cause-specific maternal mortality: A Delphi approach. *BMC Public Health* 2013; 13(Suppl 3): S12. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3847442/.

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Immediate drying and additional stimulation

- **Definition:** Percent of deliveries where healthcare provider thoroughly dries and stimulates the newborn by rubbing the back 2-3 times

- **Default data source:** Coverage data are calculated from readiness and utilization data. For details on this calculation, please see the [LiST Technical Note](#)
- The default coverage=health facility delivery * quality. You can either change utilization (health facility delivery) or quality to alter coverage. Or you can select coverage at the top box and then change coverage directly

  - **Notes:**

  - **Effect size reference:** Lee AC, Cousens S, Mullany LC, et al. Neonatal resuscitation and immediate newborn assessment and stimulation for the prevention of neonatal deaths: A systematic review, meta-analysis and Delphi estimation of mortality effect *BMC Public Health* 2011; 11(Suppl 3): S12. http://www.ncbi.nlm.nih.gov/pubmed/21501429.

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Thermal protection

- **Definition:** Percent of deliveries for which drying of the baby immediately after birth, skin-to-skin contact with mother, wrapping, and no bath in first 6 hours was performed

- **Default data source:** Coverage data are calculated from readiness and utilization data. For details on this calculation, please see the [LiST Technical Note](#)
- The default coverage=health facility delivery * quality. You can either change utilization (health facility delivery) or quality to alter coverage. Or you can select coverage at the top box and then change coverage directly

  - **Notes:**

  - **Effectiveness source:** Bhutta ZA, Das JK, Bahl R, et al. Can available interventions end preventable deaths in mothers, newborn babies, and stillbirths, and at what cost? Lancet 2014; 384(9940): 347-70. http://www.ncbi.nlm.nih.gov/pubmed/24853604

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Delayed cord clamping
- **Definition:** Clamping the umbilical cord no earlier than 1 minute after birth for preterm infants.

- **Default data source:** Coverage data are projected to be calculated from readiness and utilization data. But the readiness data for the intervention are not available and are set to 0 at baseline.
- The default coverage=health facility delivery * quality. You can either change utilization (health facility delivery) or quality to alter coverage. Or you can select coverage at the top box and then change coverage directly

  - **Notes:**

  - **Effectiveness source:** Rabe H, Gyte GML, Díaz-Rossello JL, Duley L. Effect of timing of umbilical cord clamping and other strategies to influence placental transfusion at preterm birth on maternal

and infant outcomes. Cochrane Database of Systematic Reviews 2019, Issue 9. Art. No.: CD003248. DOI: 10.1002/14651858.CD003248.pub4.

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Clean cord care

- **Definition:** Percent of deliveries where application of antiseptics to cord after cutting was performed

- **Default data source:** Coverage data are calculated from readiness and utilization data. For details on this calculation, please see the LiST Technical Note

- The default coverage=health facility delivery * quality. You can either change utilization (health facility delivery) or quality to alter coverage. Or you can select coverage at the top box and then change coverage directly

  - **Notes:**

  - **Effectiveness source**: Blencowe H, Cousens S, Mullany LC, et al. Clean birth and postnatal care practices to reduce neonatal deaths from sepsis and tetanus: A systematic review and Delphi estimation of mortality effect. BMC Public Health 2011; 11(Suppl 3): S11. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3231884/.

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MgSO4 for eclampsia

- **Definition:** Percent of pregnant women receiving intravenous magnesium sulfate (4-6g) to prevent or treat convulsions in severe pre-eclampsia or eclampsia

- **Default data source:** Coverage data are calculated from readiness and utilization data. For details on this calculation, please see the LiST Technical Note

- The default coverage=health facility delivery * quality. You can either change utilization (health facility delivery) or quality to alter coverage. Or you can select coverage at the top box and then change coverage directly

  - **Notes:**

  - **Effect size reference:** Ronsmans C, Campbell O. Quantifying the fall in mortality associated with interventions related to hypertensive diseases of pregnancy. BMC Public Health 2011; 11(Suppl 3): S8. http://www.ncbi.nlm.nih.gov/pubmed/21501459.

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Antibiotics for preterm or prolonged PROM

- **Definition:** Percent of pregnant women with premature rupture of the membranes (pPRoM) who are not in labor and receive prophylactic antibiotics.

- **Default data source:** Coverage data are calculated from readiness and utilization data. For details on this calculation, please see the LiST Technical Note

- The default coverage=health facility delivery * quality. You can either change utilization (health facility delivery) or quality to alter coverage. Or you can select coverage at the top box and then change coverage directly

  - **Notes:**

  - **Effect size reference:** Cousens S, Blencowe H, Gravett M, et al. Antibiotics for pre-term pre-labour rupture of the membranes: Prevention of neonatal deaths due to complications of preterm birth and infection *International Journal of Epidemiology* 2010; 39(Suppl 1): i34-i43. http://www.ncbi.nlm.nih.gov/pubmed/20348116.

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Antibiotics for maternal sepsis

- **Definition:** Percent of pregnant women receiving therapeutic antibiotics for initial treatment of serious infections of the pelvic organs or upper urinary tract

- **Default data source:** Coverage data are calculated from readiness and utilization data. For details on this calculation, please see the LiST Technical Note

- The default coverage=health facility delivery * quality. You can either change utilization (health facility delivery) or quality to alter coverage. Or you can select coverage at the top box and then change coverage directly

  - **Notes:**

  - **Effect size reference:** Pollard SL, Mathai M, Walker N. Estimating the impact of interventions on cause-specific maternal mortality: A Delphi approach. BMC Public Health 2013, 13(Suppl 3): S12. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3847442/

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Assisted vaginal delivery

- **Definition:** Percent of vaginal deliveries that receive the help of forceps or a vacuum device if needed

- **Default data source:** Coverage data are calculated from readiness and utilization data. For details on this calculation, please see the LiST Technical Note

- The default coverage=health facility delivery * quality. You can either change utilization (health facility delivery) or quality to alter coverage. Or you can select coverage at the top box and then change coverage directly

  - **Notes:**

  - **Effect size reference:** Pollard SL, Mathai M, Walker N. Estimating the impact of interventions on cause-specific maternal mortality: A Delphi approach. BMC Public Health 2013, 13(Suppl 3): S12. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3847442/

Yakoob MY, Ali MA, Ali MU, et al. The effect of providing skilled birth attendance   and emergency obstetric care in preventing stillbirths. BMC Public Health 2011; 11(Suppl 3):S7. https://www.ncbi.nlm.nih.gov/pubmed/21501458/

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Neonatal resuscitation

- **Definition:** Percent of deliveries that require opening the airway and ventilating newborn babies who do not spontaneously cry/breathe after birth

- **Default data source:** Coverage data are calculated from readiness and utilization data. For details on this calculation, please see the LiST Technical Note
- The default coverage=health facility delivery * quality. You can either change utilization (health facility delivery) or quality to alter coverage. Or you can select coverage at the top box and then change coverage directly

  - **Notes:**

- **Effect size reference:** Lee AC, Cousens S, Mullany LC, et al. Neonatal resuscitation and immediate newborn assessment and stimulation for the prevention of neonatal deaths: A systematic review, meta-analysis and Delphi estimation of mortality effect. BMC Public Health 2011; 11(Suppl 3): S12. http://www.ncbi.nlm.nih.gov/pubmed/21501429

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Uterotonics for postpartum hemorrhage

- **Definition:** Percent of women who require prostaglandins for prevention and management of post-partum hemorrhage

- **Default data source:** Coverage data are calculated from readiness and utilization data. For details on this calculation, please see the LiST Technical Note
- The default coverage=health facility delivery * quality. You can either change utilization (health facility delivery) or quality to alter coverage. Or you can select coverage at the top box and then change coverage directly

  - **Notes:**

- **Effect size reference:** Pollard SL, Mathai M, Walker N. Estimating the impact of interventions on cause-specific maternal mortality: A Delphi approach. BMC Public Health 2013, 13(Suppl 3): S12. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3847442/

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Manual removal of placenta

- **Definition:** Percent of deliveries that require removal of the placenta and/or retained placental tissue and membranes if not expelled within 30 minutes after childbirth

- **Default data source:** Coverage data are calculated from readiness and utilization data. For details on this calculation, please see the LiST Technical Note

- The default coverage=health facility delivery * quality. You can either change utilization (health facility delivery) or quality to alter coverage. Or you can select coverage at the top box and then change coverage directly

  - **Notes:**

  - **Effectiveness source**: Pollard SL, Mathai M, Walker N. Estimating the impact of interventions on cause-specific maternal mortality: A Delphi approach. BMC Public Health 2013, 13(Suppl 3): S12. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3847442/

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Removal of retained products of conception

- **Definition:** Percent of women that receive removal products of conception if indicated (i.e. inevitable abortion before 16 weeks, incomplete abortion, molar pregnancy or delayed postpartum hemorrhage due to retained placental fragments)

- **Default data source:** Coverage data are calculated from readiness and utilization data. For details on this calculation, please see the LiST Technical Note

- The default coverage=health facility delivery * quality. You can either change utilization (health facility delivery) or quality to alter coverage. Or you can select coverage at the top box and then change coverage directly

  - **Notes:**

  - **Effect size reference:** Pollard SL, Mathai M, Walker N. Estimating the impact of interventions on cause-specific maternal mortality: A Delphi approach. BMC Public Health 2013, 13(Suppl 3): S12. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3847442/

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Induction of labor for pregnancies lasting 41+ weeks

- **Definition:** Percent of women who are 41 or more weeks pregnant who are managed with induction of labor as appropriate.

- **Default data source:** Coverage data are calculated from readiness and utilization data. For details on this calculation, please see the LiST Technical Note

- The default coverage=health facility delivery * quality. You can either change utilization (health facility delivery) or quality to alter coverage. Or you can select coverage at the top box and then change coverage directly

  - **Notes:** The current impact of this intervention is only on stillbirths.

  - **Effect size reference:** Middleton P, Shepherd E, Morris J, Crowther CA, Gomersall JC. Induction of labour at or beyond 37 weeks' gestation. Cochrane Database Syst Rev. 2020;7(7):CD004945.

Published 2020 Jul 15. doi:10.1002/14651858.CD004945.pub5.
https://pubmed.ncbi.nlm.nih.gov/32666584/

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Antenatal corticosteroids for preterm labor

- **Definition:** Percent of women with premature labor receiving an intramuscular injection of betamethasone sodium phosphate (6mg, every 12 hours for 2 days).

- **Default data source:** The default assumption is that 0% of births receive antenatal corticosteroids; user should enter local data if possible and available.

- **Notes:** Antenatal corticosteroids (ACS) were previously included in LiST as an intervention that could be effective in reducing deaths due to prematurity in 2006, based on work for the 2005 Lancet Neonatal series. (Darmstadt GL, Bhutta ZA, Cousens S, et al. Evidence-based, cost-effective interventions: how many newborns can we save and at what cost? *Lancet* 2005; 365: 988-97. http://www.ncbi.nlm.nih.gov/pubmed/15767001.) (Mwansa-Kambafwile J, Cousens S, Hanset T, et al. Antenatal steroids in preterm labour for the prevention of neonatal deaths due to complications of preterm birth. *International Journal of Epidemiology* 2010; 39(Suppl 1): i122-i133. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2845868/.) Since that time, there has been an increasing amount of information that finds that there can be negative consequences to the use of ACS, especially when provided in weaker health care systems. (Althabe F, Belizan JM, McClure EM, et al. A population-based, multifaceted strategy to implement antenatal corticosteroid treatment versus standard care for the reduction of neonatal mortality due to preterm birth in low-income and middle-income countries: the ACT cluster-randomised trial. *Lancet* 2015; 385:629-39. http://www.ncbi.nlm.nih.gov/pubmed/25458726.) (Azad A, Costello A. Extreme caution is needed before scale-up of antenatal corticosteroids to reduce preterm deaths in low-income settings. *Lancet Global Health* 2014; 2: e191-2. http://www.sciencedirect.com/science/article/pii/S2214109X14700208.) We have decided that the best way to ensure that users do not miss-apply the possible impact of ACS on neonatal mortality is to leave the intervention in LiST, but to change the default effectiveness of this intervention to zero. This way if users to do want to model the impact of ACS when provided effectively in a stronger health care system they can do so, but will need to specify the effectiveness of the intervention.

- **Effect size reference:** McGoldrick E, Stewart F, Parker R, Dalziel SR. Antenatal corticosteroids for accelerating fetal lung maturation for women at risk of preterm birth. Cochrane Database Syst Rev. 2020 Dec 25;12(12):CD004454. doi: 10.1002/14651858.CD004454.pub4. PMID: 33368142; PMCID: PMC8094626

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Cesarean delivery

- **Definition:** Percent of women requiring surgical intervention if indicated (e.g. emergency caesarean birth for obstructed labor, uterine rupture, or fetal distress)

- **Default data source:** Coverage data for this indicator are drawn from DHS, MICS, and other nationally representative household surveys.

- **Notes**: See [LiST technical note](#) for detailed calculation method

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Blood transfusion

- **Definition:** Percent of women who require blood or blood products to prevent or manage critical conditions (i.e. postpartum haemorrhage leading to shock; loss of a large volume of blood at operative birth; and severe anaemia, especially in later pregnancy or if accompanied by cardiac failure).

- **Default data source:** Coverage data are calculated from readiness and utilization data. For details on this calculation, please see the [LiST Technical Note](#)
- The default coverage=health facility delivery * quality. You can either change utilization (health facility delivery) or quality to alter coverage. Or you can select coverage at the top box and then change coverage directly

- **Notes**:

- **Effectiveness source**: Pollard SL, Mathai M, Walker N. Estimating the impact of interventions on cause-specific maternal mortality: A Delphi approach. BMC Public Health 2013, 13(Suppl 3): S12. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3847442/

Case management of premature babies

- **Definition:** This refers to the sum of the two levels of management of prematurely born infants in the neonatal period: Kangaroo mother care and full supportive care for prematurity. See below for details on each intervention.

- **Default data source:** N/A

- **Notes:** The sum of the coverage values for the two levels of care must be less than or equal to 100%.

- **Effect size reference:** This intervention does not have a direct effect, but refers to the sum of the two indicators listed below.

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KMC - Kangaroo Mother Care

- **Definition:** Percent of premature neonates receiving Kangaroo Mother Care (KMC). KMC is defined as continuous skin-to-skin contact between a mother and her newborn as well as frequent and exclusive breastfeeding.

- **Default data source:** : Coverage data for this indicator are not typically available; it is set to 0 by default. We decided not to use the quality estimate for KMC because KMC does not necessarily need to be carried out in a health facility and the quality estimate is not accurately captured.

- **Notes:** This only benefits premature infants. The affected fraction is the percent of premature births that survive to day 3 (an average of 35.7%).

  KMC has an effect in LiST on rates of exclusive breastfeeding (through the breastfeeding promotion component of KMC). This will appear in LiST results under "changes in breastfeeding" (rather than being attributed directly to KMC).

- **Effect size reference:** Lawn JE, Mwansa-Kambafwile J, Horta BL, et al. 'Kangaroo Mother Care' to prevent deaths due to preterm birth complications. *International Journal of Epidemiology* 2010; 39(Suppl 1): i44-i54. http://www.ncbi.nlm.nih.gov/pubmed/20348117.

  Boundy EO, Dastjerdi R, Spiegelman D, et al. Kangaroo mother care and neonatal outcomes: A meta-analysis. *Pediatrics* 2016; 137(1). http://www.ncbi.nlm.nih.gov/pubmed/26702029.

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Full supportive care for prematurity

- **Definition:** Percent of prematurely born neonates who have access to and receive hospital-based full supportive care, including feeding support/IV fluids, infection prevention/management, oxygen provision, management of neonatal jaundice, nasal CPAP/IPPV (as required), and surfactant for Respiratory Distress Syndrome.

- **Default data source:** Coverage data for this indicator are not typically available. Currently set at 0 for baseline; user should enter local data if possible and available.

- **Notes:**

- **Effect size reference:** Bhutta ZA, Das JK, Bahl R, et al. Can available interventions end preventable deaths in mothers, newborn babies, and stillbirths, and at what cost? *Lancet* 2014; 384(9940: 347-70. http://www.ncbi.nlm.nih.gov/pubmed/24853604. (Appendix 40-45)

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iKMC

- **Definition:** Percent of prematurely born neonates who have access to and receive hospital-based full supportive care, including KMC, feeding support/IV fluids, infection prevention/management, oxygen provision, management of neonatal jaundice, nasal CPAP/IPPV (as required), and surfactant for Respiratory Distress Syndrome.

- **Default data source:** Coverage data for this indicator are not typically available. Currently set at 0 for baseline; user should enter local data if possible and available.

- **Notes:**

- **Effect size reference:** WHO Immediate KMC Study Group, Arya S, Naburi H, et al. Immediate "Kangaroo Mother Care" and Survival of Infants with Low Birth Weight. N Engl J Med. 2021;384(21):2028-2038. doi:10.1056/NEJMoa2026486

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7.4.3.4.4 Breastfeeding

Exclusive breastfeeding   Predominant breastfeeding   Partial breastfeeding   Any breastfeeding   No breastfeeding   Early initiation of breastfeeding   Breastfeeding promotion

In the "Breastfeeding" tab, data may be entered by either **breastfeeding prevalence** or **breastfeeding promotion**. If prevalence is selected (default), the rates of exclusive, predominant, and partial breastfeeding may be modified. If promotion is selected, the coverage of breastfeeding promotion as an intervention may be modified and breastfeeding rates are automatically calculated as a result.

Exclusive breastfeeding

- **Definition:** Percent of children receiving only breastmilk for food (plus medication, vaccines, and vitamins).

- **Default data source:** Coverage data for this indicator are drawn from DHS, MICS, and other nationally representative household surveys; however, they have been recalculated from the raw data sources to reflect the entire age period of interest.

- **Notes:** This applies to children 0-1 months and 1-5 months of age.

  If recalculated data are not available, 0-2 months can be used as a proxy for 0-1 months while 4-5 months can be used as a proxy for 1-5 months.

- **Effect size references:** Lamberti LM, Zakarija-Grković I, Fischer Walker CL, et al. Breastfeeding for reducing the risk of pneumonia morbidity and mortality in children under two: A systematic literature review and meta-analysis. *BMC Public Health* 2013; 13(Suppl 3): S18. http://www.ncbi.nlm.nih.gov/pubmed/24564728.

  Black RE, Victora CG, Walker SP, et al. Maternal and child undernutrition and overweight in low-income and middle-income countries. *Lancet* 2013; 382(9890): 427-51. http://www.ncbi.nlm.nih.gov/pubmed/23746772.

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Predominant breastfeeding

- **Definition:** Percent of children receiving only breastmilk plus water and/or other non-milk liquids such as juices (plus medication, vaccines, and vitamins).

- **Default data source:** Coverage data for this indicator are drawn from DHS, MICS, and other nationally representative household surveys; however, they have been recalculated from the raw data sources to reflect the entire age period of interest.

- **Notes:** This applies to children 0-1 months and 1-5 months of age.

  If recalculated data are not available, 0-2 months has been used as a proxy for 0-1 months while 4-5 months has been used as a proxy for 1-5 months.

- **Effect size references:** Lamberti LM, Zakarija-Grković I, Fischer Walker CL, et al. Breastfeeding for reducing the risk of pneumonia morbidity and mortality in children under two: A systematic literature review and meta-analysis. *BMC Public Health* 2013; 13(Suppl 3): S18. http://www.ncbi.nlm.nih.gov/pubmed/24564728.

  Black RE, Victora CG, Walker SP, et al. Maternal and child undernutrition and overweight in low-income and middle-income countries. *Lancet* 2013; 382(9890): 427-51. http://www.ncbi.nlm.nih.gov/pubmed/23746772.

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Partial breastfeeding

- **Definition:** Percent of children receiving breastmilk plus complementary foods and/or milk-based liquids (plus medication, vaccines, and vitamins).

- **Default data source:** Coverage data for this indicator are drawn from DHS, MICS, and other nationally representative household surveys; however, they have been recalculated from the raw data sources to reflect the exact age period of interest.

- **Notes:** This applies to children 0-1 months and 1-5 months of age.

  If recalculated data are not available, 0-2 months has been used as a proxy for 0-1 months while 4-5 months has been used as a proxy for 1-5 months.

- **Effect size references:** Lamberti LM, Zakarija-Grković I, Fischer Walker CL, et al. Breastfeeding for reducing the risk of pneumonia morbidity and mortality in children under two: A systematic literature review and meta-analysis. *BMC Public Health* 2013; 13(Suppl 3): S18. http://www.ncbi.nlm.nih.gov/pubmed/24564728.

  Black RE, Victora CG, Walker SP, et al. Maternal and child undernutrition and overweight in low-income and middle-income countries. *Lancet* 2013; 382(9890): 427-51. http://www.ncbi.nlm.nih.gov/pubmed/23746772.

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Any breastfeeding

- **Definition:** The percent of children still receiving any breastmilk.

- **Default data source:** Coverage data for this indicator are drawn from DHS, MICS, and other nationally representative household surveys; however, they have been recalculated from the raw data sources to reflect the exact age period of interest.

- **Notes:** This applies to children 6-11 months and 12-23 months of age. No health benefit is assumed to accrue to children breastfed after 24 months of age.

- **Effect size references:** Lamberti LM, Zakarija-Grković I, Fischer Walker CL, et al. Breastfeeding for reducing the risk of pneumonia morbidity and mortality in children under two: A systematic

literature review and meta-analysis*BMC Public Health*   2013; 13(Suppl 3): S18. http://www.ncbi.nlm.nih.gov/pubmed/24564728.

Black RE, Victora CG, Walker SP, et al. Maternal and child undernutrition and overweight in low-income and middle-income countries*Lancet*   2013; 382(9890): 427-51. http://www.ncbi.nlm.nih.gov/pubmed/23746772.

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No breastfeeding

- **Definition:** The percent of children not receiving any breastmilk.

- **Default data source:** Coverage data for this indicator are drawn from DHS, MICS, and other nationally representative household surveys.

- **Notes:** This can apply to children of any age group 0-23 months. It is calculated automatically as 100% minus the percentage of children in that age group with any level of breastfeeding.

- **Effect size references:** Lamberti LM, Zakarija-Grković I, Fischer Walker CL, et al. Breastfeeding for reducing the risk of pneumonia morbidity and mortality in children under two: A systematic literature review and meta-analysis*BMC Public Health*   2013; 13(Suppl 3): S18. http://www.ncbi.nlm.nih.gov/pubmed/24564728.

Black RE, Victora CG, Walker SP, et al. Maternal and child undernutrition and overweight in low-income and middle-income countries*Lancet*   2013; 382(9890): 427-51. http://www.ncbi.nlm.nih.gov/pubmed/23746772.

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Early initiation of breastfeeding

- **Definition:** The percent of children who begin breastfeeding within 1 hour of birth.

- **Default data source:** Coverage data for this indicator are drawn from DHS, MICS, and other nationally representative household surveys.

- **Notes:**

- **Effect size references:** NEOVITA Study Group. Timing of initiation, patterns of breastfeeding, and infant survival: prospective analysis of pooled data from three randomised trials*Lancet Global Health*   2016; 4(4): e266-75. https://www.ncbi.nlm.nih.gov/pubmed/27013313.

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Breastfeeding promotion

- **Definition:** Percentage of children whose mothers receive activities designed to promote breastfeeding. Breastfeeding promotion can either be one-on-one or group meetings. Promotion activities can take place within the health system, at the home/community level, or both.

  Health system interventions include the Baby-Friendly Hospital Initiative, establishment of rooming-in practices, organizational support on breastfeeding outcomes, etc.

  Home/community level interventions include one-on-one counseling by home visit or telephone, home support by father or grandparent, group counseling, group meetings, social mobilization, mass media, social media, etc.

- **Default data source:** Coverage data for this indicator are not typically available. As a proxy, the level of breastfeeding promotion is set by default to equal the percent of children 1-5 months of age that are exclusively breastfed; user should enter local data if possible and available.

- **Notes:** It is assumed that children 1-5 months of age who are exclusively breastfed do not need this behavior.

  Breastfeeding promotion is applied to breastfeeding prevalence as an increased odds of "age-appropriate breastfeeding" (that is, exclusive breastfeeding for children under 6 months, and any/continued breastfeeding for children 6-23 months). Each of the three promotion channels (health system, home/community, or both) has a different impact on breastfeeding prevalence.

- **Effect size reference:** Haroon S, Das JK, Salam RA, et al. Breastfeeding promotion interventions and breastfeeding practices: A systematic review. *BMC Public Health* 2013; 13(Suppl 3): S20. http://www.ncbi.nlm.nih.gov/pubmed/24564836.

  Bhutta ZA, Das JK, Rizvi A, et al. Evidence-based interventions for improvement of maternal and child nutrition: what can be done and at what cost? *Lancet* 2013; 382(9890): 352-77. http://www.ncbi.nlm.nih.gov/pubmed/23746776. (Supplemental material, page 16.)

  Sinha B, Chowdhury R, Sankar MJ, et al. Interventions to improve breastfeeding outcomes: A systematic review and meta-analysis. *Acta Paediatrica* 2015; 104(467): 114-34. http://www.ncbi.nlm.nih.gov/pubmed/26183031.

  Sinha B, Chowdhury R, Prakash Upadhyay R, Taneja S, Martines J, Bahl R, Jeeva Sankar M; Integrated Interventions Delivered in Health Systems, Home, and Community Have the Highest Impact on Breastfeeding Outcomes in Low- and Middle-Income Countries. Journal Nutr 2017. 147(11S): 2179S–2187S, https://doi.org/10.3945/jn.116.242321.

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7.4.3.4.5 Stunting

When the "direct entry of stunting" option is checked in the <u>LiST configuration</u> menu, the stunting tab appears in the Coverage menu. Within this tab, users may modify stunting rates either through the "single indicator for stunting" option or the "detailed indicators for stunting" option.

The purpose of the single indicator is aggregate the bottom (worst) two stunting categories to create a single percentage of children who are stunted. (For example, if 2% of children are in the <-3 Z-score category and 5% of children are in the -3 to -2 z-score category, the single indicator will display "7% of children stunted.") It also aggregates across age groups, weighting by the number of months in each age range (i.e., <1 month is assumed to represent 1/60 of children, 1-5 months is assumed to represent 5/60 of children, etc.).

When the "single indicator" option is selected, the first (baseline) year of the single indicator will be grayed out and the rest of the years will be active. In the detailed display, the first year will be active (allowing users to edit baseline data here if necessary), but the following years will be grayed out. When the "detailed display" option is selected, the single indicator will remain visible but will be entirely grayed out, and the detailed display will be fully active.

Please note that in a healthy population (assumed to have a normal distribution of height for age), approximately 2.275% of the population will fall below -2 z-scores (i.e., more than 2 standard deviations below the median). As a result, we do not recommend setting the single indicator for stunting at a rate below 2.275%, as this is below what is considered normal for a healthy population.

Stunting distributions

- **Definition:** Distribution of the percent of children falling into one of four Z-score categories for height for age: <-3Z (severe stunting), -3 to -2Z (moderate stunting), -2 to -1Z (mild stunting), and >-1Z (not stunted). Stunting reflects chronic undernutrition.

- **Default data source:** Data have been recalculated for consistency across countries, using DHS and MICS datasets. This also ensures that the values reflect the exact age groups of interest.

- **Notes:** Disaggregated data are not available for 0-1 and 1-5 months. As a proxy, the 0-6 month values are applied to both age groups. Changing single indicator of stunting is disabled retrospectively. User can use detailed stunting distribution to input stunting retrospectively. If user only has single indicator of stunting, user can calculate the detailed stunting distribution proportionally based on the existing stunting distribution.

7.4.3.4.6 Preventive

<u>Provision of appropriate fortified complementary food for food secure population</u>   <u>Provision of appropriate fortified complementary food for food insecure population</u> <u>Neonatal vitamin A supplementation</u> <u>Vitamin A supplementation</u>   <u>Zinc supplementation</u>   <u>Basic Sanitation</u>   <u>Point-of-use filtered Water</u>   <u>Piped Water</u>   <u>Hand washing with soap</u>   <u>Hygienic disposal of children's stools</u>   <u>Long lasting insecticidal nets</u>

Provision of appropriate fortified complementary food for food secure population

- **Definition:** Percent of mothers intensively counseled on the importance of continued breastfeeding beyond six months and appropriate complementary feeding practices, and given appropriate dietary supplementation. As a proxy, the percent of 6-23 month old children receiving minimum dietary diversity (4+ food groups) is used.

- **Default data source:** Coverage data for this indicator are drawn from DHS, MICS, and other nationally representative household surveys.

- **Notes:** This is applied to the food secure population. This indicator can be modified in the Household Status tab of the "Health status, mortality, and economic status" menu.

  As a default, the two complementary feeding coverage indicators are equal (using the same proxy indicator of minimum dietary diversity). The user should enter local data to differentiate between the two indicators (food secure population vs. food insecure population) if possible and available.

  The combined effect of both complementary feeding indicators will appear under Results as "appropriate complementary feeding."

  Our new meta-analysis on the effects of supplemental complementary foods showed that, of the three different types of complementary food (SQ-LNS, other fortified food mix, non-fortified local food), only SQ-LNS has a significant benefit on height-for-age z-score (HAZ) and weight-for-height z-score (WHZ). Given that 1) national programs for the provision of SQ-LNS are not yet widely available in LMICs, and 2) there are only six studies on other complementary foods that are not LNS, we decided not to restrict the intervention to the provision of SQ-LNS only, but rather to call the intervention "Provision of appropriate fortified complementary food". The estimates of efficacy from the meta-analysis on SQ-LNS trials were used for this intervention

- **Effect size reference:**

  Dewey KG, Wessells KR, Arnold CD, Prado EL, Abbeddou S, Adu-Afarwuah S, et al. Characteristics that modify the effect of small-quantity lipid-based nutrient supplementation on child growth: an individual participant data meta-analysis of randomized controlled trials. Am J Clin Nutr. 2021;114(Suppl 1):15S-42S.

  Imdad A, Yakoob MY, Bhutta ZA. Impact of maternal education about complementary feeding and provision of complementary foods on child growth in developing countries *BMC Public Health* 2011; 11(Suppl 3): S25. http://www.ncbi.nlm.nih.gov/pubmed/21501443.

  Bhutta ZA, Ahmed T, Black RE, et al. What works? Interventions for maternal and child undernutrition and survival *Lancet* 2008; 371: 417-40. http://www.ncbi.nlm.nih.gov/pubmed/18206226.

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Provision of appropriate fortified complementary food for food insecure population

- **Definition:** Percent of mothers intensively counseled on the importance of continued breastfeeding beyond six months and appropriate complementary feeding practices, and given appropriate dietary supplementation. As a proxy, the percent of 6-23 month old children receiving minimum dietary diversity (4+ food groups) is used.

- **Default data source:** Coverage data for this indicator are drawn from DHS, MICS, and other nationally representative household surveys.

- **Notes:** This is applied to the food secure population. This indicator can be modified in the Household Status tab of the "Health status, mortality, and economic status" menu.

  As a default, the two complementary feeding coverage indicators are equal (using the same proxy indicator of minimum dietary diversity). The user should enter local data to differentiate between the two indicators (food secure population vs. food insecure population) if possible and available.

  The combined effect of both complementary feeding indicators will appear under Results as "appropriate complementary feeding."

  Our new meta-analysis on the effects of supplemental complementary foods showed that, of the three different types of complementary food (SQ-LNS, other fortified food mix, non-fortified local food), only SQ-LNS has a significant benefit on height-for-age z-score (HAZ) and weight-for-height z-score (WHZ). Given that 1) national programs for the provision of SQ-LNS are not yet widely available in LMICs, and 2) there are only six studies on other complementary foods that are not LNS, we decided not to restrict the intervention to the provision of SQ-LNS only, but rather to call the intervention "Provision of appropriate fortified complementary food". The estimates of efficacy from the meta-analysis on SQ-LNS trials were used for this intervention

- **Effect size reference:** Dewey KG, Wessells KR, Arnold CD, Prado EL, Abbeddou S, Adu-Afarwuah S, et al. Characteristics that modify the effect of small-quantity lipid-based nutrient supplementation on child growth: an individual participant data meta-analysis of randomized controlled trials. Am J Clin Nutr. 2021;114(Suppl 1):15S-42S.

  Bhutta ZA, Ahmed T, Black RE, et al. What works? Interventions for maternal and child undernutrition and survival. *Lancet* 2008; 371: 417-40. http://www.ncbi.nlm.nih.gov/pubmed/18206226.

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Neonatal vitamin A supplementation

- **Definition:** Percent of neonates receive 25000 to 50 000 IU vitamin A within the first 2 to 3 days of life

- **Default data source:** Coverage data for this indicator are not typically available. Currently set at 0 for baseline; user should enter local data if possible and available.

- **Notes:** This is not the same indicator as vitamin A supplementation for children 6-59 months

- **Effect size reference:** Neonatal Vitamin A Supplementation Evidence group. Early neonatal vitamin A supplementation and infant mortality: an individual participant data meta-analysis of randomised controlled trials. Arch Dis Child. 2019 Mar;104(3):217-226. doi: 10.1136/archdischild-2018-315242. Epub 2018 Nov 13. PMID: 30425075; PMCID: PMC6556975.

Vitamin A supplementation

- **Definition:** Percent of children 6-59 months of age receiving two doses of Vitamin A during the last 12 months.

- **Default data source:** UNICEF - Vitamin A coverage. http://data.unicef.org/nutrition/vitamin-a. Updated annually.

- **Notes:** The full indicator is typically not available from a DHS/MICS or other household survey. However, the percent of children 6-59 months receiving 1 dose of Vitamin A in the past 6 months can be used if necessary from these sources.

  This is applied to vitamin A deficient population.

  The impact is based on Imdad et al. The effectiveness is calculated from Black et al web annex Table 12 and 13. Taking the reciprocal of RR due to Vitamin A deficiency (VAD) to get the RR of vitamin A intervention, effectiveness of Vitamin A supplementation=1-(1/RR due to VAD)

- **Effect size reference:** Imdad A, Yakoob MY, Sudfeld CR, et al. Impact of vitamin A supplementation on infant and childhood mortality. *BMC Public Health* 2011; 11(Suppl 3): S20. http://www.ncbi.nlm.nih.gov/pubmed/21501438.

  Black RE, Victora CG, Walker SP, et al. Maternal and child undernutrition and overweight in low-income and middle-income countries [published correction appears in Lancet. 2013. 2013 Aug 3;382(9890):396]. Lancet. 2013;382(9890):427-451. doi:10.1016/S0140-6736(13)60937-X https://pubmed.ncbi.nlm.nih.gov/23746772/

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Zinc supplementation

- **Definition:** Percent of children 12-59 months of age who are given daily supplements of 10mg zinc.

- **Default data source:** Coverage data for this indicator are not typically available. Currently set at 0 for baseline; user should enter local data if possible and available.

- **Notes:** This is not the same indicator as zinc treatment for diarrhea.

- **Effect size reference:** Yakoob MY, Theodoratou E, Jabeen A, et al. Preventive zinc supplementation in developing countries: impact on mortality and morbidity due to diarrhea, pneumonia and malaria. *BMC Public Health* 2011; 11(Suppl 3): S23. http://www.ncbi.nlm.nih.gov/pubmed/21501441.

  Black RE, Victora CG, Walker SP, et al. Maternal and child undernutrition and overweight in low-income and middle-income countries. *Lancet* 2013; 382(9890): 427-51. http://www.ncbi.nlm.nih.gov/pubmed/23746772. (Supplemental material, page 18-19.)

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Basic Sanitation
- **Definition:** Percent of the population in households using an improved sanitation facility (defined as flush or pour flush to piped sewer system, septic tank, or pit latrine; ventilated improved pit (VIP) latrine; pit latrine with slab; or composting toilet), which are not shared

- **Default data source:** WHO/UNICEF Joint Monitoring Program (JMP) for Water Supply and Sanitation.

- **Notes:**

- **Effect size reference:** Wolf J, Hunter PR, Freeman MC, Cummings O, Clasen T, Bartram J, et al. Impact of drinking water, sanitation and handwashing with soap on childhood diarrhoeal disease: updated meta□analysis and meta□regression. Trop Med Int Health. 2018; 23(5): 508-525. doi:10.1111/tmi.13051 https://pubmed.ncbi.nlm.nih.gov/29537671/

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Point-of-use filtered water

- **Definition:** Percent of the population in households with point-of-use filtered water with safe storage in the household

- **Default data source:** Coverage data for this indicator are drawn from DHS, MICS, and other nationally representative household surveys.

- **Notes:**

- **Effect size reference:** Wolf J, Hunter PR, Freeman MC, Cummings O, Clasen T, Bartram J, et al. Impact of drinking water, sanitation and handwashing with soap on childhood diarrhoeal disease: updated meta□analysis and meta□regression. Trop Med Int Health. 2018; 23(5): 508-525. doi:10.1111/tmi.13051 https://pubmed.ncbi.nlm.nih.gov/29537671/

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Piped water

- **Definition:** Percent of the population in households with a piped improved drinking water source

- **Default data source:** WHO/UNICEF Joint Monitoring Program (JMP) for Water Supply and Sanitation.

- **Notes:**

- **Effect size reference:** Wolf J, Hunter PR, Freeman MC, Cummings O, Clasen T, Bartram J, et al. Impact of drinking water, sanitation and handwashing with soap on childhood diarrhoeal disease: updated meta□analysis and meta□regression. Trop Med Int Health. 2018; 23(5): 508-525. doi:10.1111/tmi.13051 https://pubmed.ncbi.nlm.nih.gov/29537671/

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Hand washing with soap

- **Definition:** Percent of the population living in households with a handwashing facility on premises with soap and water available

- **Default data source:** WHO/UNICEF Joint Monitoring Program (JMP) for Water Supply and Sanitation.

- **Notes:**

- **Effect size reference:** Fischer Walker et al., publication forthcoming

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Hygienic disposal of children's stools

- **Definition:** Percent of children's stools that are disposed of safely and contained. Stools are considered to be contained if: 1) the child always uses a toilet/latrine, 2) the feces are thrown in the toilet/latrine, or 3) the feces are buried in the yard.

- **Default data source:** Coverage data for this indicator are drawn from DHS, MICS, and other nationally representative household surveys.

- **Notes:** In some countries, utilization of disposable diapers may be considered hygienic disposal, but this is included on a country-by-country basis as the DHS/MICS has chosen.

  Currently, this intervention is assumed to have no quantifiable effect on diarrhea incidence, child mortality, or any other outcome modeled in LiST due to a lack of high quality evidence, as determined by a 2010 Cochrane review on the topic.

- **Effect size reference:** Clasen TF, Bostoen K, Schmidt W-P, *et al.* Interventions to improve disposal of human excreta for preventing diarrhoea. Cochrane Database of Systematic Reviews 2010, Issue 6. Art. No.: CD007180. doi: 10.1002/14651858.CD007180.pub2

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Long lasting insecticidal nets

- **Definition:** Percent of households owning at least one long lasting insecticidal bednet (LLIN).

- **Default data source:** Coverage data for this indicator are drawn from DHS, MICS, and other nationally representative household surveys. This includes Malaria Indicator Surveys.

- **Notes:** For historical trends where data on IRS are not available, data on percent of households with one or more ITN are used instead; this is considered a reasonable minimum bound. Data points where this substitution is used are indicated in the source notes. ITNs are assumed to have been introduced in 2000, so a linear "scale-up" trend from zero in 1999 to the first available data point for the country is automatically computed.

  The indicator can be substituted with trends in "children sleeping under an ITN," but the estimate will be conservative. The default effect size is based on household ownership, not utilization. Note that any bednet (treated or untreated) is not an adequate indicator.

- **Effect size reference:** Eisele TP, Larsen D, Steketee RW. Protective efficacy of interventions for preventing malaria mortality in children in Plasmodium falciparum endemic areas. *International Journal of Epidemiology* 2010; 39(Suppl 1): i88-i101. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2845865/.

   Radeva-Petrova D, Kayentao K, Ter Kuile FO, et al. Drugs for preventing malaria in pregnant women in endemic areas: Any drug regimen versus placebo or no treatment. *Cochrane Database Syst Rev* 2014. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4498495/.

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7.4.3.4.7 Vaccines

BCG   Polio   Pentavalent   DPT   Hib   HepB   Pneumococcal   Rotavirus   Measles   Meningococcal A   Diarrheal vaccine pathogen B   Diarrheal vaccine pathogen C   Malaria vaccine   Vaccine D

Vaccines given to children in their first year of life have protective effects until they are five years of age. When editing vaccine coverage, users will have to specify coverage in the four years prior to the base year of coverage of the LiST module. This will allow the model to correctly compute the protective effects of vaccines for children in different age groups in a given year.

For each vaccine, the number of doses that is considered "full coverage" is displayed on the "Vaccines" tab. To enter coverage of incomplete doses and/or supplemental vaccination, double-click on the relevant vaccine. There are no default effectiveness estimates for supplemental vaccination (additional doses or "boosters"), although there are effectiveness estimates for suboptimal dosing. The sum of all the doses must be less than or equal to 100% of children.

If a supplemental campaign is being modeled, check the box for "supplemental vaccination - campaign implemented" in the relevant year. Then enter data on geographic coverage, low and high age groups targeted, and the average number of doses per child. Select the radial button at the top of the page to enter either the number of doses provided or the percent of target population reached, and then enter those values at the bottom of the page. Default values are not available for this section of the model.

BCG

- **Definition:** Percent of live births receiving at least one dose of BCG.

- **Default data source:** Default data from WHO/UNICEF Estimates of National Immunization Coverage (https://www.who.int/immunization/monitoring_surveillance/data/en/), updated annually. These data can be replaced with DHS/MICS data if necessary.

- **Notes:** BCG is included in LiST to indicate that it is an important intervention delivered during the first five years of life.

- **Effect size reference:** The current assumption is that BCG has no measurable impact upon under-five mortality.

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Polio

- **Definition:** Percent of children who survive the first year of life who have received at least three doses of polio vaccine.

- **Default data source:** Default data from WHO/UNICEF Estimates of National Immunization Coverage (https://www.who.int/immunization/monitoring_surveillance/data/en/), updated annually. These data can be replaced with DHS/MICS data if necessary.

- **Notes:** Polio vaccination is included in LiST to indicate that it is an important intervention delivered during the first five years of life.

- **Effect size reference:** The current assumption is that polio vaccination has no measurable impact upon under-five mortality.

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Pentavalent

- **Definition:** Percent of children who survive the first year of life who have received 3 doses of pentavalent vaccine.

- **Default data source:** N/A Currently set at 0 for baseline

- **Notes:** If coverage of DTP, Hib, and HepB are at the same level, users can use that as coverage of Pentavalent. Changing the pentavalent vaccine coverage will automatically change the coverage of DPT, Hib, and HepB. See the individual vaccines for effect information.

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DPT

- **Definition:** Percent of children who survive the first year of life who have received 3 doses of DPT vaccine.

- **Default data source:** Default data from WHO/UNICEF Estimates of National Immunization Coverage (https://www.who.int/immunization/monitoring_surveillance/data/en/), updated annually. These data can be replaced with DHS/MICS data if necessary.

- **Notes:** The effect of DPT is only on pertussis mortality. There is currently no impact on tetanus or diphtheria mortality. Default herd effect is 0. Note that herd immunity can be adjusted if desired.

- **Effect size reference:** Fulton TR, Phadke VK, Orenstein WA, et al. Protective Effect of Contemporary Pertussis Vaccines: A Systematic Review and Meta-analysis*Clinical Infectious Diseases* 2016; 62(9): 1100-1100. http://www.ncbi.nlm.nih.gov/pubmed/26908803.

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Hib

- **Definition:** Percent of children who survive the first year of life who have received 3 doses of Hib vaccine.

- **Default data source:** Default data from WHO/UNICEF Estimates of National Immunization Coverage (https://www.who.int/immunization/monitoring_surveillance/data/en/), updated annually. These data can be replaced with DHS/MICS data if necessary.

- **Notes:** There is default herd effect applied. Note that herd immunity can be adjusted.

- **Effect size reference:**
  For pneumonia:
  Griffiths UK, Clark A, Gessner B, et al. Dose-specific efficacy of Haemophilus influenzae type b conjugate vaccines: A systematic review and meta-analysis of controlled clinical trials. *Epidemiology and Infection* 2012; 140(8): 1343-1355. http://www.ncbi.nlm.nih.gov/pubmed/22583474.

  For meningitis:
  Davis, S., Feikin, D., & Johnson, H. L. (2013). The effect of Haemophilus influenzae type B and pneumococcal conjugate vaccines on childhood meningitis mortality: a systematic review. BMC public health, 13 Suppl 3(Suppl 3), S21. https://doi.org/10.1186/1471-2458-13-S3-S21

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HepB

- **Definition:** Percent of live births who have received at least three doses of Hepatitis B vaccine.

- **Default data source:** Default data from WHO/UNICEF Estimates of National Immunization Coverage (https://www.who.int/immunization/monitoring_surveillance/data/en/), updated annually. These data can be replaced with DHS/MICS data if necessary.

- **Notes:** Hepatitis B vaccination is included in LiST to indicate that it is an important intervention delivered during the first five years of life.

- **Effect size reference:** The current assumption is that hepatitis B vaccination has no measurable impact upon under-five mortality.

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Pneumococcal

- **Definition:** Percent of children who survive the first year of life who have received 3 doses of Pneumococcal vaccine.

- **Default data source:** Default data from WHO/UNICEF Estimates of National Immunization Coverage (https://www.who.int/immunization/monitoring_surveillance/data/en/), updated annually. These data can be replaced with DHS/MICS data if necessary.

- **Notes:** There is default herd effect applied. Note that herd immunity can be adjusted.

- **Effect size reference:**
  For pneumonia:
  Lucero MG, Dulalia VE, Nillos LT, et al. Pneumococcal conjugate vaccines for preventing vaccine-type invasive pneumococcal disease and pneumonia with consolidation on x-ray in children under

two years of age. *Cochrane Database Syst Rev* 2009. http://www.ncbi.nlm.nih.gov/pubmed/19821336.

For meningitis:
Davis, S., Feikin, D., & Johnson, H. L. (2013). The effect of Haemophilus influenzae type B and pneumococcal conjugate vaccines on childhood meningitis mortality: a systematic review. BMC public health, 13 Suppl 3(Suppl 3), S21. https://doi.org/10.1186/1471-2458-13-S3-S21

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Rotavirus

- **Definition:** Percent of children who survive the first year of life who have received 2 or 3 doses of Rotavirus vaccine (according to manufacturer's schedule).

- **Default data source:** Default data from WHO/UNICEF Estimates of National Immunization Coverage (https://www.who.int/immunization/monitoring_surveillance/data/en/), updated annually. These data can be replaced with DHS/MICS data if necessary.

- **Notes:** The effect size varies by geographic region. There is default herd effect applied. Note that herd immunity can be adjusted.

- **Effect size reference:** Lamberti, L. M., Ashraf, S., Walker, C. L., & Black, R. E. (2016). A Systematic Review of the Effect of Rotavirus Vaccination on Diarrhea Outcomes Among Children Younger Than 5 Years. The Pediatric infectious disease journal, 35(9), 992–998. https://doi.org/10.1097/INF.0000000000001232

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Measles

- **Definition:** Percent of children who survive the first year of life who have received 1 dose of measles vaccine.

- **Default data source:** Default data from WHO/UNICEF Estimates of National Immunization Coverage (https://www.who.int/immunization/monitoring_surveillance/data/en/), updated annually. These data can be replaced with DHS/MICS data if necessary.

- **Notes:** The default model is appropriate for vaccines which have already been rolled out, but not necessarily for new vaccines. The model may not necessarily correctly estimate the time to elimination of disease (at the very extremes of coverage) but will correctly model control of disease. There is default herd effect applied. Note that the impact of herd immunity can be adjusted. Default herd effect is 100% at 95% coverage. The effect of supplemental campaigns and second-opportunity measles vaccination can also be calculated.

- **Effect size reference:** Sudfeld CR, Navar AM, Halsey NA. Effectiveness of measles vaccination and vitamin A treatment. *International Journal of Epidemiology* 2010; 39(Suppl 1): i48-i55. http://www.ncbi.nlm.nih.gov/pubmed/20348126.

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Meningococcal A

- **Definition:** Percent of children who survive the first year of life who have received a full course of Meningococcal A vaccine (according to manufacturer's schedule).

- **Default data source:** Default data from official country reported coverage estimates (https://www.who.int/immunization/monitoring_surveillance/data/en/), updated annually.

- **Notes:** For default, we assume a single dose is full coverage.

- **Effect size reference:** Daugla DM, Gami JP, Gamougam K, et al. Effect of a serogroup A meningococcal conjugate vaccine (PsA–TT) on serogroup A meningococcal meningitis and carriage in Chad: a community study. Lancet 2014; 383: 40–47. http://dx.doi.org/10.1016/S0140-6736(13)61612-8.

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Diarrheal Vaccine Pathogen B

- **Definition:** Percent of children children who survive the first year of life who have received a full course of Pathogen B vaccine.

- **Default data source:** N/A

- **Notes:** For default, we assume a single dose is full coverage. This is a placeholder for research purposes. There is no default effect size. To use this indicator, the user must enter data. This indicator is not available in the standard model.

- **Effect size reference:** None.

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Diarrheal Vaccine Pathogen C

- **Definition:** Percent of children children who survive the first year of life who have received a full course of Pathogen C vaccine.

- **Default data source:** N/A

- **Notes:** For default, we assume a single dose is full coverage. This is a placeholder for research purposes. There is no default effect size. To use this indicator, the user must enter data. This indicator is not available in the standard model.

- **Effect size reference:** None.

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Malaria Vaccine

- **Definition:** Percent of children who survive the first year of life who have received a full course of malaria vaccine.

- **Default data source:** There is no data currently available.

- **Notes:** For default, we assume a single dose is full coverage. Please see this [technical note](#) for more detailed information on effect size.

- **Effect size reference:** The RTS,S Clinical Trials Partnership. New England Journal. N Engl J Med. 2011;365:1463–76. https://www.ncbi.nlm.nih.gov/pubmed/22007715.

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Vaccine D

- **Definition:** Percent of children who survive the first year of life who have received a full course of vaccine D.

- **Default data source:** N/A

- **Notes:** For default, we assume a single dose is full coverage. This is a placeholder for research purposes. There is no default effect size. To use this indicator, the user must enter data. This is indicator is not available in the standard model.

- **Effect size reference:** None.

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7.4.3.4.8 Curative

[Case management of neonatal sepsis/pneumonia](#)   [Oral antibiotics](#)   [Injectable antibiotics](#)   [Full supportive care for sepsis/pneumonia](#)   [ORS](#)   [Antibiotics - treatment for dysentery](#)   [Zinc - treatment of diarrhea](#)   [Oral antibiotics for pneumonia](#) [Oxygen and pulse oximetry for pneumonia](#)   [Vitamin A - treatment of measles](#)   [Antimalarials - Artemesinin compounds for malaria](#)   [Therapeutic feeding for severe wasting](#)   [Treatment for moderate acute malnutrition](#)   [Cotrimoxazole](#)   [ART (for children)](#)

Case management of neonatal sepsis/pneumonia

- **Definition:** This refers to the sum of the three levels of case management for neonatal sepsis/pneumonia: oral antibiotics, injectable antibiotics, and full supportive care. See below for details on each intervention.

- **Default data source:** N/A

- **Notes:** The sum of the three levels of care must be less than or equal to 100%.

- **Effect size reference:** This intervention does not have a direct effect, but refers to the sum of the three indicators listed below.

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Oral antibiotics

- **Definition:** Percent of neonates with suspected sepsis/pneumonia treated with oral antibiotics.

- **Default data source:** Coverage data for this indicator are not typically available. Currently set at 0 for baseline; user should enter local data if possible and available.

- **Notes:**

- **Effect size reference:** Zaidi AK, Ganatra HA, Syed S, et al. Effect of case management on neonatal mortality due to sepsis and pneumonia. *BMC Public Health* 2011; 11(Suppl 3): S13. http://www.ncbi.nlm.nih.gov/pubmed/21501430.

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Injectable antibiotics

- **Definition:** Percent of neonates with suspected sepsis/pneumonia treated with injectable antibiotics.

- **Default data source:** Coverage data for this indicator are not typically available. Coverage of antibiotics for maternal sepsis is used as a proxy because similar set of supplies were needed for the two interventions.

- **Notes:**

- **Effect size reference:** Zaidi AK, Ganatra HA, Syed S, et al. Effect of case management on neonatal mortality due to sepsis and pneumonia. *BMC Public Health* 2011; 11(Suppl 3): S13. http://www.ncbi.nlm.nih.gov/pubmed/21501430.

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Full supportive care for sepsis/pneumonia

- **Definition:** Percent of neonates with suspected sepsis/pneumonia treated with hospital-based full supportive care, including oxygen, IV fluids, IV antibiotics, blood transfusion, phototherapy, etc. as needed.

- **Default data source:** Coverage data for this indicator are not typically available. Currently set at 0 for baseline; user should enter local data if possible and available.

- **Notes:**

- **Effect size reference:** Zaidi AK, Ganatra HA, Syed S, et al. Effect of case management on neonatal mortality due to sepsis and pneumonia. *BMC Public Health* 2011; 11(Suppl 3): S13. http://www.ncbi.nlm.nih.gov/pubmed/21501430.

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ORS - oral rehydration solution

- **Definition:** Percent of children 0-59 months with suspected diarrhea treated with oral rehydration solution (ORS), including sachets or pre-mixed solutions. This indicator does not include homemade sugar-salt solution or recommended home fluids due to lack of adequate data.

- **Default data source:** Coverage data for this indicator are drawn from DHS, MICS, and other nationally representative household surveys.

- **Notes:** It is assumed that 88% of diarrhea mortality is susceptible to treatment with ORS. (Source: Rahman AE, Moinuddin M, Molla M, et al. Childhood diarrhoeal deaths in seven low- and middle-income countries. Bulletin WHO 2014. https://www.ncbi.nlm.nih.gov/pubmed/25378757.) To change this assumption, visit the Effectiveness menu to alter the affected fraction.

  This is an indicator of appropriate diarrhea treatment. This does not suggest that increased fluids, continuous feeding, or ORT should not be recommended.

- **Effect size reference:** Munos M, Fischer Walker CL, Black RE. The effect of oral rehydration solution and recommended home fluids on diarrhea mortality. *International Journal of Epidemiology* 2010; 39(Suppl 1): i75-i87. http://www.ncbi.nlm.nih.gov/pubmed/20348131.

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Antibiotics - treatment for dysentery

- **Definition:** Percent of children 0-59 months with bloody diarrhea who receive appropriate antibiotic treatment (including ciprofloxacin, ceftriaxone, and pivmecillinam).

- **Default data source:** Coverage data for this indicator are drawn from DHS, MICS, and other nationally representative household surveys.

- **Notes:** It is assumed that 12% of diarrhea mortality is due to dysentery, and hence susceptible to treatment with this intervention. (Source: Rahman AE, Moinuddin M, Molla M, et al. Childhood diarrhoeal deaths in seven low- and middle-income countries. Bulletin WHO 2014. https://www.ncbi.nlm.nih.gov/pubmed/25378757.) To change this assumption, visit the Effectiveness menu to alter the affected fraction.

- **Effect size reference:** Das JK Ali A, Salam RA, et al. Antibiotics for the treatment of Cholera, Shigella and Cryptosporidium in children. *BMC Public Health* 2013; 13(Suppl 3): S10. http://www.ncbi.nlm.nih.gov/pubmed/24564492.

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Zinc - treatment of diarrhea

- **Definition:** Percent of children 0-59 months with suspected diarrhea treated with 20mg of zinc daily.

- **Default data source:** Coverage data for this indicator are drawn from DHS, MICS, and other nationally representative household surveys.

- **Notes:**

- **Effect size reference:** Fischer Walker CL, Black RE. Zinc for the treatment of diarrhea: Effect on diarrhea morbidity, mortality and incidence of future episodes. *International Journal of Epidemiology* 2010; 39(Suppl 1): i63-i69. http://www.ncbi.nlm.nih.gov/pubmed/20348128.

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Oral antibiotics for pneumonia

- **Definition:** Percent of children with suspected pneumonia (symptoms of acute respiratory infection) for whom advice or treatment was sought from a health facility or provider.

- **Default data source:** Coverage data for this indicator are drawn from DHS, MICS, and other nationally representative household surveys. Careseeking for pneumonia is used as a proxy for treatment with oral antibiotics.

- **Notes:**

- **Effect size reference:** Theodoratou E, Al-Jilaihawi S, Woodward F, et al. The effect of case management on childhood pneumonia mortality in developing countries *International Journal of Epidemiology* 2010; 39(Suppl 1): i155-i171. http://www.ncbi.nlm.nih.gov/pubmed/20348118.

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Oxygen and pulse oximetry for pneumonia

- **Definition:** Percent of children 1-59 months with severe pneumonia with hypoxemia for whom oxygen therapy with pulse oximetry monitoring were provided

- **Default data source:** Coverage data for this indicator are not typically available. Currently set at 0 for baseline; user should enter local data if possible and available.

- **Notes:**

- **Effect size reference:** Lam F, Stegmuller A, Chou VB, Graham HR. Oxygen systems strengthening as an intervention to prevent childhood deaths due to pneumonia in low-resource settings: systematic review, meta-analysis and cost-effectiveness. BMJ Glob Health. 2021;6(12):e007468. doi:10.1136/bmjgh-2021-007468

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Vitamin A - treatment of measles

- **Definition:** Percent of children with measles treated with Vitamin A.

- **Default data source:** Coverage data for this indicator are not typically available. As a proxy, the percent of children 6-59 months receiving two doses of vitamin A in 12 months (preventive Vitamin A supplementation) is used.

- **Notes:**

- **Effect size reference:** Sudfeld CR, Navar AM, Halsey NA. Effectiveness of measles vaccination and vitamin A treatment *International Journal of Epidemiology* 2010; 39(Suppl 1): i48-i55. http://www.ncbi.nlm.nih.gov/pubmed/20348126.

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Antimalarials - Artemesinin compounds for malaria

- **Definition:** Percent of children treated within 48 hours of the onset of fever in malaria-endemic areas with an artmesinin-containing compound (artemisinin-based combination therapy, or ACT).

- **Default data source:** Coverage data for this indicator are drawn from DHS, MICS, and other nationally representative household surveys. This includes Malaria Indicator Surveys.

- **Notes:** Historic data often measures treatment with any antimalarial in 48 hours, rather than ACTs specifically. These data can be used to create a historical trend, but there is not a good way to translate "any antimalarial" into an estimate of ACT coverage due to differing levels of effectiveness.

- **Effect size reference:** Thwing J, Eisele TP, Steketee RW. Protective efficacy of malaria case management for preventing malaria mortality in children: A systematic review for the Lives Saved Tool. *BMC Public Health* 2011; 11(Suppl 3): S14. http://www.ncbi.nlm.nih.gov/pubmed/21501431.

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Therapeutic feeding for severe wasting (severe acute malnutrition (SAM))

- **Definition:** Percent of severely wasted children (<-3 Z-score) receiving therapeutic feeding. Therapeutic feeding is outpatient treatment including supplementation with ready-to-use therapeutic foods (RUTF) and maternal education.

- **Default data source:** Coverage estimates calculated from:
  The UNICEF Global SAM Management Update Tool (NutriDash): 2012 – 2016. Available at www.acutemalnutrition.org.
  The UNICEF-WHO-The World Bank Group Joint Child Malnutrition Estimates: 2012 – 2016. Available at www.acutemalnutrition.org.

- **Notes:** Therapeutic feeding is only applied to the percent of children severely wasted. It shifts children from the severely wasted category to moderately (-3 to -2 Z-score) and mildly (-2 to -1 Z-score) wasted categories.

- **Effect size reference:** Lenters LM, Wazny K, Webb P, et al. Treatment of severe and moderate acute malnutrition in low- and middle-income settings: A systematic review, meta-analysis and Delphi process. *BMC Public Health* 2013; 13(Suppl 3): S23. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3847503/.

  Bhutta ZA, Das JK, Rizvi A, et al. Evidence-based interventions for improvement of maternal and child nutrition: what can be done and at what cost? *Lancet* 2013; 382(9890): 352-77. http://www.ncbi.nlm.nih.gov/pubmed/23746776. (Supplemental material, page 15.)

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Treatment for moderate acute malnutrition (MAM)

- **Definition:** Percent of moderately wasted children (-3 to -2 Z-score) receiving outpatient treatment including supplementation with ready-to-use supplementary foods (RUSF) and maternal education.

- **Default data source:** Coverage data for this indicator are not typically available. Currently set at 0 for baseline; user should enter local data if possible and available.

- **Notes:** Treatment for MAM shifts children from the moderately wasted category into the mildly wasted category (-2 to -1 Z-score).

- **Effect size reference:** Lenters LM, Wazny K, Webb P, et al. Treatment of severe and moderate acute malnutrition in low- and middle-income settings: A systematic review, meta-analysis and Delphi process. *BMC Public Health* 2013; 13(Suppl 3): S23. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3847503/.

  Bhutta ZA, Das JK, Rizvi A, et al. Evidence-based interventions for improvement of maternal and child nutrition: what can be done and at what cost? *Lancet* 2013; 382(9890): 352-77. http://www.ncbi.nlm.nih.gov/pubmed/23746776. (Supplemental material, page 15.)

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Cotrimoxazole

- **Definition:** Coverage and effectiveness of AIDS and HIV interventions are specified in the AIM module.

- **Default data source:**

- **Notes:**

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ART (for children)

- **Definition:** Coverage and effectiveness of AIDS and HIV interventions are specified in the AIM module.

- **Default data source:**

- **Notes:**

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7.4.3.4.9 Wasting

When the "direct entry of wasting" option is checked in the [LiST configuration](#) menu, the wasting tab appears in the Coverage menu. Within this tab, users may modify wasting rates either through the "single indicator for wasting" option or the "detailed indicators for wasting" option.

The purpose of the single indicator is aggregate the bottom (worst) two wasting categories to create a single percentage of children who are wasted. (For example, if 2% of children are in the <-3 Z-score category and 5% of children are in the -3 to -2 z-score category, the single indicator will display "7% of children wasted.") It also aggregates across age groups, weighting by the number of months in each age range (i.e., <1 month is assumed to represent 1/60 of children, 1-5 months is assumed to represent 5/60 of children, etc.).

When the "single indicator" option is selected, the first (baseline) year of the single indicator will be grayed out and the rest of the years will be active. In the detailed display, the first year will be active (allowing users to edit baseline data here if necessary), but the following years will be grayed out. When the "detailed display" option is selected, the single indicator will remain visible but will be entirely grayed out, and the detailed display will be fully active.

Please note that in a healthy population (assumed to have a normal distribution of height for age), approximately 2.275% of the population will fall below -2 z-scores (i.e., more than 2 standard deviations below the median). As a result, we do not recommend setting the single indicator for wasting at a rate below 2.275%, as this is below what is considered normal for a healthy population.

Wasting distributions

- **Definition:** Distribution of the percent of children falling into one of four Z-score categories for weight for height: <-3Z (severe wasting), -3 to -2Z (moderate wasting), -2 to -1Z (mild wasting), and >-1Z (not wasted). Wasting reflects acute undernutrition.

- **Default data source:** Data have been recalculated for consistency across countries, using DHS and MICS datasets. This also ensures that the values reflect the exact age groups of interest.

- **Notes:** Disaggregated data are not available for 0-1 and 1-5 months. As a proxy, the 0-6 month values are applied to both age groups. Disaggregated data are not available for 0-1 and 1-5 months. As a proxy, the 0-6 month values are applied to both age groups. Changing single indicator of wasting is disabled retrospectively. User can use detailed wasting distribution to input wasting retrospectively. If user only has single indicator of wasting, user can calculate the detailed wasting distribution proportionally based on the existing wasting distribution.

7.4.3.4.10 Fertility risks

[Maternal age and birth order](#)   [Birth intervals](#)

Maternal age and birth order

- **Definition:** Distribution of all births, categorized by the maternal age and the parity of the birth.

- **Default data source:** Data are drawn from DHS, MICS, and other nationally representative household surveys; the sum of all categories must add to 100%.

- **Notes:**

- **Effect size reference:** Kozuki N, Lee ACC, Silveira MF, et al. The associations of parity and maternal age with small-for-gestational-age, preterm, and neonatal and infant mortality: a meta-analysis. *BMC Public Health* 2013; 13(Suppl 3): S2. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3847520/. (Relative risks are from unpublished calculations associated with the paper.)

Birth intervals

- **Definition:** Distribution of all births, categorized by the number of months between births.

- **Default data source:** Data are drawn from DHS, MICS, and other nationally representative household surveys; the sum of all categories must add to 100%.

- **Notes:**

- **Effect size reference:** Kozuki N, Lee ACC, Silveira MF, et al. The associations of birth intervals with small-for-gestational-age, preterm, and neonatal and infant mortality: a meta-analysis. *BMC Public Health* 2013; 13(Suppl 3): S3. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3847557/. (Relative risks are from unpublished calculations associated with the paper.)

7.4.3.5 Efficacy

1. The efficacy editor groupings show the default values for the efficacy (the percent of deaths due to a specific cause that are reduced by the intervention) and affected fraction (the percent of deaths due to a specific cause which are potentially able to be impacted by a specific intervention) for each maternal or child health intervention. References for efficacy data are included under each intervention in the "Coverage" section of the Help manual.

2. The first four editor groupings (maternal, stillbirth, <1, and 1-59 months) have editor screens organized by cause of death, which display the default values by intervention and age grouping if applicable.

3. You may view only the interventions that affect the relevant cause of death (on the selected tab), which is the default presentation; or you may choose to display the full list of interventions (including those with no default effect on the relevant cause of death) by checking the box "Show all items."

4. If you would like to alter the default values for efficacy or affected fraction, click anywhere inside the editor to make it active and enter the data. Because the default values are based on rigorous scientific study and are unlikely to need alteration, the cell for any default value that you change will be highlighted in **red** to show that the value has been changed from the default value.

5. Click the "Display default" button if you would like to view the value for a cell that was entered in comparison to the default value. If at any time you decide that you would prefer to revert to the default values over the data that you have entered, click the "Restore defaults" button, and the default values for all indicators in the editor will be restored. The "Restore defaults" button works separately for each editor and will only restore the values in the editor you are working on.

7.4.3.5.1 Efficacy of interventions (maternal)

The efficacy editor for interventions related to maternal deaths shows the default values for the efficacy (the percent of deaths due to a specific cause that are reduced by the intervention) and affected fraction (the percent of deaths due to a specific cause which are potentially able to be impacted by a specific intervention) for each maternal or child health intervention. Please see the "Efficacy" help page for more information.

The tabs in this editor are organized by cause of death and display the default values by intervention. Please note that each tab contains a table for "efficacy of interventions (maternal)," which includes interventions prior to delivery/birth (periconceptual and pregnancy periods) and after delivery/birth, and a table for "maternal delivery effectiveness," which includes interventions given during delivery/birth.

See help pages on Coverage for information on effect size references.

7.4.3.5.2 Efficacy of interventions (stillbirths)

The efficacy editor for interventions related to maternal deaths shows the default values for the efficacy (the percent of deaths due to a specific cause that are reduced by the intervention) and affected fraction (the percent of deaths due to a specific cause which are potentially able to be impacted by a specific intervention) for each maternal or child health intervention. Please see the "Efficacy" help page for more information.

The tabs in this editor are organized by cause of death and display the default values by intervention.

Folic acid fortification/supplementation
- **Affected fraction:** is the product of percent folate insufficient and percent of stillbirth due to neural tube defects.
- **Data Source**: Beal T, Massiot E, Arsenault JE, Smith MR, Hijmans RJ. Global trends in dietary micronutrient supplies and estimated prevalence of inadequate intakes. PLoS One. 2017;12(4):1–20. http://dx.doi.org/10.1371/journal.pone.0175554
- Blencowe H, Kancherla V, Moorthie S, Darlison MW, Modell B. Estimates of global and regional prevalence of neural tube defects for 2015: a systematic analysis. Ann N Y Acad Sci. 2018;1414(1):31-46. doi:10.1111/nyas.13548

See help pages on Coverage for information on effect size references.

7.4.3.5.3 Efficacy of interventions (<1 month)

The efficacy editor for interventions related to maternal deaths shows the default values for the efficacy (the percent of deaths due to a specific cause that are reduced by the intervention) and affected fraction (the percent of deaths due to a specific cause which are potentially able to be impacted by a specific intervention) for each maternal or child health intervention. Please see the "Efficacy" help page for more information.

The tabs in this editor are organized by cause of death and display the default values by intervention. Please note that each tab contains a table for "efficacy of interventions (<1 month)," which includes interventions prior to delivery/birth (periconceptual and pregnancy periods) and after delivery/birth, and a table for "neonatal delivery efficacy," which includes interventions given during delivery/birth.

Folic acid fortification/supplementation
- **Affected fraction:** is the product of percent of folate insufficient and percent of congenital abnormality due to neural tube defects.

- **Data Source**: Beal T, Massiot E, Arsenault JE, Smith MR, Hijmans RJ. Global trends in dietary micronutrient supplies and estimated prevalence of inadequate intakes. PLoS One. 2017;12(4):1–20. http://dx.doi.org/10.1371/journal.pone.0175554
- Blencowe H, Cousens S, Modell B, et al. Folic acid to reduce neonatal mortality from neural tube disorders. International Journal of Epidemiology 2010; 39(Suppl 1): i110-i121. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2845867/

See help pages on Coverage for information on effect size references.

7.4.3.5.4 Efficacy of interventions (1-59 months)

The efficacy editor for interventions related to maternal deaths shows the default values for the efficacy (the percent of deaths due to a specific cause that are reduced by the intervention) and affected fraction (the percent of deaths due to a specific cause which are potentially able to be impacted by a specific intervention) for each maternal or child health intervention. Please see the "Efficacy" help page for more information.

The tabs in this editor are organized by cause of death and display the default values by intervention and by age grouping (1-5 months, 6-11 months, 12-23 months, and 24-59 months).

See help pages on Coverage for information on effect size references.

7.4.3.5.5 Efficacy of interventions on incidence

The efficacy editor for interventions related to maternal deaths shows the default values for the efficacy (the percent of deaths due to a specific cause that are reduced by the intervention) and affected fraction (the percent of deaths due to a specific cause which are potentially able to be impacted by a specific intervention) for each maternal or child health intervention. Please see the "Efficacy" help page for more information.

The tabs in this editor are organized by disease incidence and age grouping, and display the default values by intervention.

See help pages on Coverage for information on effect size references.

7.4.3.5.6 Herd efficacy of vaccines

The tabs in this editor are organized by vaccine type (this editor also includes bednets) and display the herd effect by age cohort, coverage rate of the vaccine, and affected disease (tabs at the bottom of the table).

Declines in mortality from vaccines are modeled based on vaccine effectiveness specific to the child receiving the immunization and a herd effect. The herd effect is modeled as the percent of unprotected children (the sum of unvaccinated population and the vaccine failures) who are protected by the reduced transmission of the disease resulting from increased immunization rates. The parameters for herd effect are entered as the percent of the unprotected population which is protected for five-percentage-point bands beginning at 0 percent coverage. Currently, the defaults for herd effect are zero for all vaccines except Hib, Pneumococcal, Rotavirus, and Measles vaccines. For details on how the herd effects were calculated for various vaccines in LiST, please see this LiST Technical Note

7.4.3.5.7 Efficacy and risks for birth outcomes

This editor shows the risk factors and the efficacy of a range of interventions on birth outcomes.

Low Birth Weight Coversion Factors

- **Definition:** Calculation of percentage of total births that are low birth weight (LBW) based on region-specific pooled proportions of LBW births in each birth outcome category.

- **Notes:**

- **Effect size reference:** Kozuki N, Katz J, Clermont A, Walker N and the Child Health Epidemiology Reference Group SGA-Preterm Birth Working Group. New Option in the Lives Saved Tool (LiST) Allows for the Conversion of Prevalence of Small-for-Gestational-Age and Preterm Births to Prevalence of Low Birth Weight: A Delphi approach. *BMC Public Health* 2013; 13(Suppl 3): S12. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3847442/.

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7.4.3.5.8 Efficacy of nutrition interventions

This editor shows the efficacy of nutrition interventions, not directly on mortality, but rather on the intermediate variables of stunting rates, severe wasting rates, maternal anemia, and breastfeeding promotion.

Please note that efficacy information may be displayed as relative risks, odds ratios, or recovery rates within the various tabs.

Association between linear growth and education attainment

- **Definition:** The association between early-childhood growth (measured by HAZ-height-for-age z-score) and educational attainment (measured by years of schooling).

- **Notes:** Assuming education improvements resulting from improved early-childhood growth are a linear function of HAZ for children who are stunted at age 2, it is estimated that 0.47 additional year of schooling per unit increase in HAZ at the age of 2 years. Based on scaled up nutrition interventions, average increase in height-for-age z-score among 2 years old stunted children within in the same birth cohort is estimated, assuming normal distribution. Since the estimated growth status at 2 years old for children in the last projection year's birth cohort is not available. Results on additional year of schooling are not available for the last year's birth cohort.

- **Effect size reference:** Adair LS, Fall CH, Osmond C, et al. Associations of linear growth and relative weight gain during early life with adult health and human capital in countries of low and middle income: findings from five birth cohort studies. Lancet. 2013;382(9891):525-534. doi:10.1016/S0140-6736(13)60103-8. https://pubmed.ncbi.nlm.nih.gov/23541370/.

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Association between education attainment and economic returns

- **Definition:** The relative gains in wages that children born today will experience as a result of their additional education attainment in the future.

- **Notes:** The additional education attainment is resulted from the reduction in stunting. The country-level estimates on economic returns of schooling are retrieved from systematic reviews. Since the estimated growth status at 2 years old for children in the last projection year's birth cohort is not available. Results on additional lifetime earnings are not available for the last year's birth cohort.

- **Effect size reference:** Fink G, Peet E, Danaei G, et al. Schooling and wage income losses due to early-childhood growth faltering in developing countries: national, regional, and global estimates. Am J Clin Nutr. 2016;104(1):104-112. doi:10.3945/ajcn.115.123968. https://pubmed.ncbi.nlm.nih.gov/27357091/

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See help pages on Coverage for information on other effect size references.

7.4.3.5.9 Impact of undernutrition on mortality

Impact of stunting on mortality   Impact of wasting on mortality   Impact of birth outcomes on mortality
    Impact of breastfeeding on mortality
Impact of anemia on maternal mortality

Building on the information in the "Efficacy of nutrition interventions," this editor calculates the impact of stunting rates, wasting rates, birth outcomes (SGA/preterm), and breastfeeding rates on child mortality. The tabs in this editor are organized by cause of death and age cohort or birth outcome group. Please note that efficacy information is displayed as relative risks.

Impact of stunting on mortality

- **Effect size reference:** Olofin I, McDonald CM, Ezzati M, et al. Associations of Suboptimal Growth with All-Cause and Cause-Specific Mortality in Children under Five Years: A Pooled Analysis of Ten Prospective Studies. PLOS One 2013; 8(5): e64636. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3667136/.

- **Notes:**

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Impact of wasting on mortality

- **Effect size reference:** Olofin I, McDonald CM, Ezzati M, et al. Associations of Suboptimal Growth with All-Cause and Cause-Specific Mortality in Children under Five Years: A Pooled Analysis of Ten Prospective Studies. PLOS One 2013; 8(5): e64636. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3667136/.

- **Notes:**

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Impact of birth outcomes on mortality

- **Effect size reference:** Katz J, Lee AC, Kozuki N, et al. Mortality risk in preterm and small-for-gestational-age infants in low-income and middle-income countries: A pooled country analysis. *Lancet*   2013; 382(9890): 417–25. http://www.ncbi.nlm.nih.gov/pubmed/23746775.

- **Notes:** This paper indicates the overall effect on neonatal mortality. Through discussion with the authors, we made some assumptions about which causes of death are likely to be associated with the term and gestational-age status of the children. Since the overall effect is applied to only a subset of births, this will underestimate the total impact. The relative risk associated with

prematurity is calculated based on the strong assumption that there is no selection in which premature births are prevented.

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Impact of breastfeeding on mortality

- **Effect size reference:** Black RE, Victora CG, Walker SP, et al. Maternal and child undernutrition and overweight in low-income and middle-income countries *Lancet* 2013; 382(9890): 427-51. http://www.ncbi.nlm.nih.gov/pubmed/23746772. (Supplementary material - Web Table 17.)

  NEOVITA Study Group. Timing of initiation, patterns of breastfeeding, and infant survival: prospective analysis of pooled data from three randomised trials *Lancet Global Health* 2016; 4(4): e266-75. https://www.ncbi.nlm.nih.gov/pubmed/27013313.

- **Notes:**

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Impact of anemia on maternal mortality

- **Effect size reference:** Murray-Kolb, L. Maternal Mortality, Child Mortality, Perinatal Mortality, Child Cognition, and Estimates of Prevalence of Anemia due to Iron Deficiency. CHERG.org 2010. http://cherg.org/publications/iron-report.pdf

  Affected fraction: % of women with severe anemia. Source: Stevens GA, Finucane MM, De-Regil LM, et al. Global, regional, and national trends in haemoglobin concentration and prevalence of total and severe anaemia in children and pregnant and non-pregnant women for 1995-2011: a systematic analysis of population-representative data. Lancet Global Health 2013; 1(1): e16-25.

- **Notes:** The relationship between anemia and maternal mortality in LiST is explained in this Technical Note. http://www.livessavedtool.org/images/documents/Technical_Notes/Anemia-and-Maternal-Mortality-in-LiST.pdf

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7.4.3.6 Results

Number of stunting cases averted   Number of anemia cases prevented

Number of stunting cases averted

The number of stunting cases averted were calculated by age cohorts in every calendar year. If an 18-month-old stunted child receives intervention in the first year of scale up (Year i) and becomes healthy. The model counts it as one stunting case averted among 12-23 months children in Year i. From Year i+1 to Year i+3, the child's stunting status enter the calculations again among 24-59 months

If the child maintains the healthy status, the model will also count it as one stunting case averted among 24-59 months children every year from Year i+1 to Year i+3. Therefore it is not appropriate to add up numbers across calendar years and interpret the sum as total number of stunting cases averted among children 1-59 months. The correct interpretation for the sum is total stunting-years averted among children 1-59 months.

Number of anemia cases prevented

To estimate the cumulative number of anemia cases prevented among pregnant women, user can select the result--"Number of anemia cases prevented". For pregnant women, since different groups of women become pregnant every calendar year, user can add up numbers across calendar years to get cumulative number of anemia cases prevented. For non-pregnant women, since same group of women remained non-pregnant every calendar year, to get a rough estimate of the sum, users should apply the reduction in prevalence of anemia to the total population of non-pregnant women.

7.4.3.7 Costing inputs

7.4.3.7.1 Introduction

LiST Costing provides a means to estimate the financial and human resources required to deliver a package of services.

Questions can be explored such as: How much funding is required to achieve the goals of the strategic plan? What goals can be achieved with the current resources? What is the impact of alternative patterns of resource allocation in terms of both the associated costs and achieved goals of the strategic plan?

By using LiST Costing in conjunction with the standard LiST module, scenarios can be developed by varying parameters such as costs inputs, coverage rates of interventions, and/or other inputs, and can then be evaluated based on the impact on maternal and child mortality and morbidity and cost associated with delivering the package of services.

7.4.3.7.2 Configuration

If LiST costing is activated, the user has access to an additional tab in LiST configuration called Currency and Inflation. On this tab the user can set the exchange rate, designate what currency they wish to enter costs in, and enter an inflation rate.

If the user wishes to enter costs in dollars, they need to check the box to say that they wish to enter costs in US dollars instead of local currency. Results can be produced in either currency, based on the selection in the results editor. They will be calculated between currencies based on the exchange rate entered in the currency and inflation editor.

7.4.3.7.3 Staff baseline data

Staff baseline data is pre-populated with assumptions for salaries, benefits, and time utilization drawn from WHO CHOICE. These data points are used to estimate a cost per minute, which is combined with information from Treatment Inputs editors to estimate the labor costs for delivering the various interventions. Users are encouraged to revise these assumptions if more accurate local information is available.

Salaries are assumed to be an annual salary for a full time staff person, denoted in local currency or US dollars, depending on the user's selection in LiST Configuration. Benefits are calculated as a percentage of those salary costs, and entries for days per year and time worked per day are used to convert the assumptions for what a full-time staff person can do into a cost per minute.

7.4.3.7.4 Intervention costing (target population, population in need, coverage, and delivery channels)

The determinants for intervention costs are the **number of people** receiving the intervention and the **quantity of resources** required to deliver the intervention per person.

In order to calculate the number of people receiving the services, LiST costing includes data entry fields for the following:
- Target population
- Population in need

Coverage is drawn from the [coverage menu in LiST](#).

All three of the above must have data entered into them in order for the tool to be able to estimate the number of people receiving the intervention each year. The calculation pattern is as follows:

Target population * population in need * coverage = number of services

Target population: This is defined as the population that could possibly receive the intervention. There are global defaults available for each intervention.

Examples of target populations include:
- Pregnant women
- Children aged <1 month
- Children aged 0-59 months
- Children aged 1-59 months
- Total population

Target populations, which represent age-determined groups, are drawn from the [DemProj module](#), as are demographic events such as pregnancies or births. The user can select from a drop-down list of default populations or specify the target population of each intervention as shown below:

Select a target population for each intervention

Intervention	Target population		Sex	Starting age	Ending age
Safe abortion services	Abortions	∨			
Post abortion case management	Abortions	∨			
Ectopic pregnancy case management	Pregnant women	∨			
Blanket iron supplementation/fortification	Total population	∨			
Pregnancy					
Routine					
TT - Tetanus toxoid vaccination	Pregnant women	∨			
IPTp - Intermittent preventive treatment of malaria during pregnancy	Pregnant women / Live births / Live births and stillbirths / Children < 1 / Abortions / Children 0-59 months / Children 1-59 months / Children 6-59 months				
Syphilis detection and treatment					
Nutritional					
Calcium supplementation	Pregnant women	∨			
Micronutrient supplementation (iron and multiple micronutrients)		∨			
Iron supplementation in pregnancy	Pregnant women	∨			

Find next   Find previous   Highlight

☑ Enable searching

The second option is to select a target population based on age and sex. In order to do this, select Custom Target population from the drop-down menu, and enter the characteristics needed (age range and sex).

The third option is to enter the target population directly, but selecting "Direct entry" from the drop-down menu. When a user does this, they will have the opportunity to enter a numeric target population of their choice by double clicking on the name of the intervention.

Population in need: This section is used to identify what share of the target population requires the intervention, per year. For most preventive care interventions, the share will be 100%. For example, antenatal care will be required for all pregnant women. Population in need is determined by incidence and prevalence of conditions, as well as by treatment guidelines.

In some instances, the population in need may be > 100%. For example, consider management of diarrhea with ORS. The target population is children aged 0-59 months. If we put 100% population in need, this means that each child will on average receive the intervention once per year. However, in many settings, the incidence of diarrhea may be greater than 1.0. For example, if the incidence of diarrhea in children is estimated at 3.5 episodes per year, the population in need will be 350%. If 1% of

all diarrhea cases are estimated to be severe, then the population in need for treatment of severe diarrhea will be 3.5% (calculated as 350% x 1%).

For another example, take treatment of malaria in pregnant women. Here the target population is pregnant women, and the population in need is the percentage of pregnant women who will need treatment of malaria, per year.

Detailed information about the sources for each of the default assumptions is found in the Intervention Assumptions Manual (pending).

7.4.3.7.5 Treatment inputs

Treatment inputs for each intervention specify the required drugs and consumable supplies (e.g., gloves, syringes), provider time, and number of inpatient days and outpatient visits needed for the effective provision of an intervention. These are drawn from intervention assumptions developed for the OneHealth Tool (http://www.who.int/choice/onehealthtool/en/) and documented in the Intervention Assumptions Manual (pending). These inputs were developed based on WHO norms and guidelines where available, with expert input where explicit guidance was not available. Drugs and consumable supply prices are extracted from international sources such as the MSH Drug Price Indicator Guide, UNICEF supply catalog, and the Global Price Reporting Mechanism.

Default treatment inputs and prices are provided at a global level, with no variation for different countries, but these inputs can be adjusted to fit the country context. Users can change the assumed quantities of drugs and supplies used, amount of provider time and number of visits, as well as the unit price for any input. In a typical country application, country teams review all data assumptions thoroughly, particularly country-specific input prices, and change the default data to reflect the specific country context and their norms or practices.

See the examples below for tetanus toxoid vaccination. For each intervention, similar to this example, users can review the existing inputs for drugs and supplies, provider time by type, and inpatient and outpatient visits. Each element can be edited, including adding other drugs and supplies, and changing the unit cost (by double-clicking on the unit cost cell).

TT - Tetanus toxoid vaccination, clinic level

Drugs and supplies   Medical personnel   Outpatient visits and inpatient days

Drugs and supplies

Drug/Supply	Percent receiving this aspect of the treatment	Note	Number of units	Times per day	Days per case	Units per case	Unit cost (USD) (2017)	Cost per average case (USD) (2017)
Tetanus toxoid, injection	100.0		1.0	1	2	2	0.06	0.12
Syringe, needle + swab	100.0		1.0	1	2	2	0.05	0.10
Total cost								0.22

TT - Tetanus toxoid vaccination, clinic level

Drugs and supplies   Medical personnel   Outpatient visits and inpatient days

Medical personnel time requirements

Staff type	Percent treated by	Note	Minutes	Number of days/visits	Total minutes
Midwives	100.0			3	2	5.00
Total minutes					5.00

TT - Tetanus toxoid vaccination, clinic level

Drugs and supplies   Medical personnel   Outpatient visits and inpatient days

Number of outpatient visits and inpatient days per average case

	Percent receiving	Note	Units per case	Total visits
Outpatient visits	100.0		2	2.0
Total visits				2.0

7.4.3.7.6 Other - recurrent and capital costs

The costs per outpatient visit and inpatient day (OPVs/IPDs) have been calculated by the World Health Organization at the country level and are available from the WHO-CHOICE website. Note that the costs that are available on their website are defined by the World Health Organization to be the "hotel" cost portion of both OPVs and IPDs, that is, all costs except drugs and laboratory costs. In other words, the OPV and IPD costs contain both other direct costs (ODCs) and indirect costs, as well as personnel costs and the cost of consumables.

By estimating the proportion of the WHO-CHOICE OPV/IPD cost that is associated with ODCs and indirect costs, those proportions can then be applied to adjust the cost of the OPV/IPD for each intervention in LiST. To calculate the costs associated with ODCs and indirect costs for each intervention, we can use the number of OPV/IPD for each intervention, already available in LiST, and multiply those quantities by the proportion of the country-specific cost of one OPV/IPD that is attributable to ODCs and indirect costs.

These costs are then multiplied by the number of OPVs/IPDs associated with each service to give a total cost for other recurrent and capital costs.

7.4.3.7.7 Delivery channels

LiST costing provides the option to differentiate the delivery of services by delivery channel or level of service delivery – that is, via community, outreach, clinic, and hospital-level care. Users can specify different treatment inputs (drugs and supplies, personnel time, and outpatient visits/inpatient days for each level), based on the different access to resources at different levels in the country. Results can also be produced by level, allowing analysis of the cost implications in a shift of services between levels, as well as the amount of resources required to expand services.

The delivery channels editor allows users to enter base and target distributions of services (i.e. what proportion of each intervention is delivered at each level in the first and final years of the projection). A linear interpolation takes place between these points to fill in the interim years.

A default distribution is provided, based on expert consultation by WHO experts.

7.4.3.7.8 Program costs

Program cost categories can be configured or changed using the Add/Edit/Delete buttons. These costs are intended to capture the above service delivery costs associated with the delivery of the RMNCH package of services found in LiST and LiST costing. Users have the option of entering costs either as a percentage of direct costs, or as an absolute number (each program cost can be configured as percentage or absolute number using the drop down selection).

Default program cost categories and percentages have been provided, based on SUN nutrition plan costing exercises, the EPIC immunization studies, and National AIDS Spending Assessments (see detailed table below). Users are encouraged to adapt these cost categories and the assumed level of costs based on recent country-specific data if available.

Category	Option		Source
Programme-specific human resources	Percentage	1%	
Training	Percentage	1%	EPIC studies
Supervision	Percentage	2%	EPIC studies
Monitoring and evaluation	Percentage	2%	EPIC studies
Infrastructure	Percentage	2%	NASA
Transport	Percentage	2%	Comprehensive vaccine planning (WHO)
Communication, media, and outreach	Percentage	1%	SUN costed nutrition plans
Advocacy	Percentage	1%	EPIC studies
General programme management	Percentage	2%	EPIC studies
Community health worker training	Percentage	1%	Expert estimates (no data)
Other	Percentage	0%	

Total   15%

7.4.4   Methodology

Choosing an optimum set of child health interventions for maximum mortality impact is important within resource-poor policy environments. The Lives Saved Tool (LiST) is a computer model that estimates the mortality and stillbirth impact of scaling up proven maternal and child health interventions. To model the impacts on child health, LiST uses the demographic engine of Spectrum (DemProj), which calculates the numbers of deaths disaggregated by age band, while using neonatal, infant, and under-five mortality rates from LiST. It then overlays the AIDS mortality directly related to children from the AIDS Impact Module (AIM), based upon the prevalence of AIDS among the entire population to calculate the total number of deaths due to AIDS. The non-AIDS individual causes of death are then overlayed on all of the non-AIDS deaths in children in the neonatal period and the 1-59 month period.

LiST estimates the mortality impact via five age bands: 0 months, 1-5 months, 6-11 months, 12-23 months, and 24-59 months. For each of these age bands, reductions in cause-specific mortality are estimated by applying intervention effectivenesses and affected fractions to intervention coverage changes. The impacts of interventions are calculated separately for eight causes of death in the neonatal period, and nine causes of death in the 1-59 month period. Corrections are then made to this simple equation to correct for the impact of coverage achieved prior to the projection period. The impact of interventions are calculated in groups such that periconceptual, antenatal, and childbirth interventions, sequentially, have the first "opportunity" to prevent mortality, with preventive interventions impacting mortality next and leaving those that are more curative in nature to reduce the remaining mortality that is not reduced. Then each child who is "saved" is then capable of dying of other causes during the subsequent age period.

Simultaneously, nutrition interventions can impact either nutritional status or directly impact mortality. In the former case, LiST acts as a cohort model where current nutritional statuses such as stunting or intrauterine growth restriction impact the probability of stunting as the cohort ages. LiST links with DemProj to estimate the deaths and deaths averted due to the reductions in mortality rates.

In addition, AIM calculates the impact of PMTCT, Cotrimoxazole, and ART for children and then feeds these directly back into the LiST model as deaths averted by these interventions. The Family Planning (FamPlan) and DemProj modules can also feed into the LiST model via changes in the number of births, resulting in varying numbers of child deaths upon which to apply the intervention impacts.

LiST also estimates the impact of interventions on maternal mortality. The calculations are very similar to those for child mortality. One difference is that all women aged 15-49 are treated as a single group in the calculations, and interventions act directly on one or more of the nine causes of death (i.e., none affect an intermediate nutrition status). Family planning, although not an intervention in LiST, may also impact maternal mortality by reducing the incidence of abortion, which is a maternal cause of death in the LiST model. The reductions in maternal mortality are translated into maternal mortality ratios, which are then translated into maternal deaths and maternal deaths averted via live births calculated in DemProj.

Finally, LiST estimates the impact of interventions on stillbirths. Different from the other outputs, the reductions are analyzed by when the stillbirth occurs in pregnancy – either antepartum or intrapartum. As with maternal mortality, stillbirth reductions are translated into stillbirth rates, and stillbirths via pregnancies in DemProj.

For more information on the general methodology of LiST please see Walker N, Tam Y, Friberg I. Overview of the Lives Saved Tool (LiST). *BMC Public Health* 2013; 13(Suppl 3): S1. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3847271/.

For more information on the calculations within LiST, please see Winfrey W, McKinnon R, Stover J. Methods used in the Lives Saved Tool (LiST). *BMC Public Health* 2011, 11(Suppl 3): S32. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3231906/.

Please visit www.livessavedtool.org for a complete list of papers using LiST and other resources.

7.4.5 AIM-LiST analysis

Open Spectrum then open the country projection of interest

- Go to the modules tab of the Spectrum menu and select LiST.

- Click the Configuration tab.

- Do NOT change the "base year of coverage" unless you have new cause-of-death data. The "First year of intervention program" is the baseline year from which you want to calculate your scale-up. Click "OK" when finished.

- Click "Close." Under the "home" tab of the Spectrum menu, select "Save Projection As" and rename the file.

Choose the new file that you just saved

- Under the home tab of the Spectrum menu select "Open projection" and choose the new file that you have just saved.

- Choose "Load and rename" when a window pops up that asks "Projection is already loaded, what would you like to do?"

- Rename the file to indicate that you are doing an AIM analysis.

- When you are finished you should have two projections, with different names, but with identical data. You will see the projection names at the bottom right corner of the screen.

Begin work in AIM

- From the modules tab of the Spectrum menu, select AIM.

- Choose the projection in which you want to change the coverage of the AIDS interventions.

- Eight tabs will appear: Eligibility for treatment, Program statistics, Advanced options, Incidence, Sex/Age pattern, Results, Validation, and Changes. Default data will be provided. You will likely not want to change the default data, unless you have more recent treatment or incidence data through the EPP file prepared by the statistics division of the National AIDS commission, or you are working on a sub-national projection with significantly different estimates. Adult ART does not affect child mortality estimates.

- To change the "Maternal-to-Child Transmission" values, click the "Program statistics" tab and then "PMTCT."

- Enter the yearly values for the prophylaxis/treatment options. For any given year, choose either the number or percent option. If you select number, then percent should equal 0; if you select percent, then number should equal 0. The No Prophylaxis percent and Total Number change automatically. If you prefer, you can convert the default number of users to a percent of users by clicking on the bottom right of the screen.

- Then, in the "Child treatment" tab edit the number/percent receiving cotrimoxazole and ART as needed. Then click "OK."

- Review the CD4 count threshold for eligibility for treatment by age, under "Child" in the "Eligibility for treatment tab." Then click "OK."

- To input incidence, you may do so through the "Configuration" choice in the drop-down menu under Incidence or through the "Direct incidence option" in the same menu. The user may choose instead to enter prevalence by choosing "Validation" - "Prevalence" - "Enter/edit data."

- The "Sex/Age pattern" and "Advance options" default values should also be reviewed, but it is unlikely that the user will want to deviate from the default values provided by research experts. When finished, click "OK." Under the "Home" tab of the spectrum menu select "Save projection" and choose the projection you have just altered (i.e. Senegal-AIM).

Display results

- From the modules tab of the Spectrum menu, select LiST.

- Choose the display of interest under the "Results" menu. Typically one will want to look at "Additional Deaths prevented in children under 5 years of age relative to impact year."

- The lives saved by each intervention is the difference between the baseline and the AIM projection. In the example below, PMTCT saved 3,109 – 2,051 = 1,058 lives.

Additional deaths prevented in children under-five years of age by intervention relative to impact year (Total (0-60 months))

	2015	2016	2017	2018	2019	2020
Test1						
Pregnancy						
PMTCT - Prevention of mother to child transmission ...	1,004	1,800	1,988	2,036	2,057	2,051
Curative after birth						
Cotrimoxazole	149	187	231	275	319	362
ART	195	233	256	282	309	338
test1-AIM						
Pregnancy						
PMTCT - Prevention of mother to child transmission ...	2,660	4,530	4,713	4,437	3,890	3,109
Curative after birth						
Cotrimoxazole	326	326	427	567	724	850
ART	442	448	560	772	1,156	1,748

7.4.6 FamPlan-LiST analysis

Open Spectrum and then open the country projection of interest

- Go to the modules tab of the Spectrum menu and select LiST.

- Click the Configuration tab.

- Do NOT change the "base year of coverage" unless you have new cause-of-death data. The "First year of intervention program" is the baseline year from which you want to calculate your scale-up from. Click "OK" when finished.

- Click "Close." Under the "Home" tab of the Spectrum menu, select "Save Projection As" and rename the file.

Choose the new file that you just saved

- Under the home tab of the Spectrum menu select "Open projection" and choose the new file that you have just saved.

- Choose "Load and rename" when a window pops up that asks "Projection is already loaded, what would you like to do?"

- Rename the file to indicate that you are doing an FamPlan analysis.

- When you are finished you should have two projections, with different names, but with identical data. You will see the projection names at the bottom right corner of the screen.

Begin work in FamPlan

- From the modules tab of the Spectrum menu, select FamPlan.

- Choose the projection in which you want to change the family planning information.

- If you plan on altering the Contraceptive Prevalence Rate (CPR) in your population, click on the "Goal" tab.

- By default, the CPR is set to match the values in the most recent survey and then extrapolated to the end of the projection to maintain the UN Population division TFR estimates. Change the values in the target year and use the interpolate and duplicate functions as needed. Click "OK."

- If you want to change the proportion of women using different methods for contraception, click on the "Family Planning" tab.

- Choose the "Method Mix" tab under the "Family planning" menu item. Adjust the proportions of women using different contraceptive methods. The total must equal to 100%. Use the duplicate, interpolate and normalize functions as needed. When finished, click "OK."

NOTE: If you have a different goal, i.e. TFR, or unmet need, you will need to visit the "Configuration" button first and read the FamPlan help manual.

Display results

- From the modules tab of the Spectrum menu, select LiST.

- Choose the display of interest under the "Results" menu. Typically one will want to look at "Additional Deaths prevented in children under 5 years of age relative to impact year."

- As you can see below, there are fewer deaths in the population in which the contraceptive prevalence was increased. This occurs due to the reduction in the number of pregnancies and births. There is no impact on mortality rates.

LiST Deaths in children under-five years... ⊠

Deaths in children under-five years of age (Total (0-60 months))

	2015	2016	2017	2018	2019	2020
Test1						
Total (0-60 months)	55,606	56,048	56,980	58,060	59,177	60,328
<1 month	17,404	17,841	18,282	18,730	19,180	19,635
1-59 months	38,202	38,207	38,698	39,330	39,997	40,694
test1-FP						
Total (0-60 months)	61,044	61,320	62,129	63,090	64,078	62,243
<1 month	19,112	19,532	19,942	20,355	20,767	19,263
1-59 months	41,932	41,788	42,187	42,735	43,311	42,980

7.5   Goals
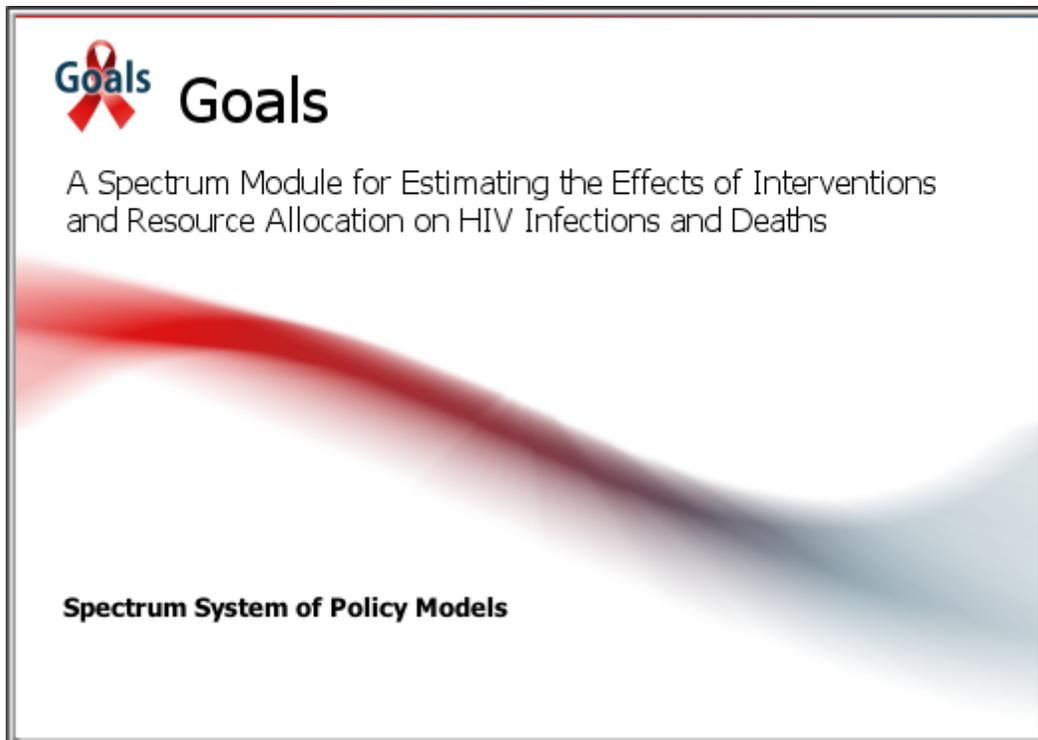
7.5.1   What is Goals?

The Goals model is intended to support strategic planning at the national level by providing a tool to link program goals and funding. The model can help answer several key questions:

- How much funding is required to achieve the goals of the strategic plan?

- What goals can be achieved with the available resources?

- What is the effect of alternate patterns of resource allocation on the achievement of program goals?

The Goals model does not provide all the answers. It is intended to assist planners in understanding the effects of funding levels and allocation patterns on program impact. The model can help planners understand how funding levels and patterns can lead to reductions in HIV incidence and prevalence and improved coverage of treatment, care and support programs. It does not, however, calculate the "optimum" allocation pattern or recommend a specific allocation of resources between prevention, care and mitigation.

Goals is intended for use by national programs to explore the effects of different funding levels and patterns on national goals. It is generally implemented by a multi-disciplinary team composed of participants with various areas of expertise (demography, epidemiology, health finance, planning) representing different aspects of society (government, civil society, private sector, donors). A technical team works together to implement the model for the first time. Then the model is used in interactive workshops with planners and stakeholders to explore the effects of different program configurations on the provision of care and support and the prevention of new HIV infections. Through this interaction participants gain a better understanding of the dynamics of funding and impact. This prepares them to develop realistic budgets and goals that reflect their priorities. A typical application may take two weeks to set up the model, which can then be used with occasional updating to support annual planning exercises and ad hoc studies.

Designing and implementing national program HIV/AIDS is complex and important. Prevention, treatment, and palliative care costs are a significant component of the health budget. In most national strategic plans, although the activities to be undertaken are clearly outlined, these activities are not tied to specific prevalence goals the countries want to attain. By projecting estimates of future program needs, Goals can help planners respond to changes in intervention, care, and drug therapy funding. It should be noted that when trying to provide high-quality HIV/AIDS services, political, legal, and ethical considerations sometimes take priority over economic issues in determining the most cost-effective resource allocation pattern.

Designing and incorporating an HIV/AIDS program into strategic plan goals is a complicated process requiring skilled and dedicated personnel, appropriate technologies, legislation, infrastructure, and adequate funds. Note that, although Goals can be used to show how the distribution of funds will affect HIV/AIDS prevalence and coverage, it does not imply that program goals can be achieved merely by allocating the necessary funds.

7.5.2   Why make Goals projections?

The Goals model may be used for several purposes. Millions of dollars are spent annually to prevent HIV infection without a thorough understanding of the most effective way to allocate these funds. Therefore, one reason to use the Goals model is to estimate the impact of budget decisions on the achievement of HIV/AIDS program goals. By anticipating the consequences and trade-offs of allocation options, Goals can support the decision making process and may include the following activities:

- Estimating reductions in HIV prevalence

- Estimating increases in coverage of essential care and treatment services

- Allocating resources between prevention and care programs

- Setting priorities for high-risk populations

By understanding how resources need to be spent to achieve proposed goals, these simulations can help planners choose goals that are attainable and useful. For example, information on the magnitude of the economic effects of STIs on the prevalence and incidence of HIV may move the allocation of resources away from other sectors and toward the health sector.

Another important use of the Goals model is the examination of alternative resource allocation strategies. Rather than simply project current expenditures into the future, the analyst can ask, "How much funding is required to achieve national coverage for the most cost-effective interventions? How much funding is required to provide palliative care to everyone who needs it? How many pregnant women can be treated with ARV to prevent maternal-to-child transmission? Would the allocation of additional expenditures to ART have a significant impact on HIV prevalence goals?"

The Goals model is not intended to replace the tools and techniques used in day-to-day operations. It is intended to support policy dialogue about the allocation of resources and its contribution to achieving the goals of the HIV/AIDS national strategic plan. It is designed to support discussion of long-term issues, such as reduction in HIV incidence and prevalence, the implications of initiating ART, alternative options in preventing mother-to-child transmission, and the funding requirements to meet national HIV and STI health goals.

7.5.3 Steps in making a Goals projection

There are six major steps involved in using Goals:

1. Form a national team to implement the model. The model needs to be implemented by a national team that can be trained in the use of the model and can apply it to the national strategic plan. This team will generally receive some initial training in the use of the model and then extensive training as the model is set up and used. Ideally the model will be implemented by a multi-disciplinary team composed of participants with various areas of expertise (demography, epidemiology, health finance, planning) representing different aspects of society (government, civil society, private sector, donors).

2. Collect data on HIV/STI prevalence, sexual behavior, and the costs of prevention and care programs. The Goals model contains a large amount of information obtained from published studies on the cost and impact of prevention and care programs. This information can be used or replaced with locally available data. It also requires national data on the population size and distribution, adult HIV and STI prevalence and sexual behavior (e.g., condom use and number of partners).

3. Adapt the model to the national strategic plan. The model is designed to show the consequences of allocating funds to various prevention, care and treatment programs. To do this, the activities in the strategic plan need to be linked (or mapped) to the categories in the model. This may require adding some line items for activities that are in the plan but not in the model, or mapping the budget categories in the plan to those used in the model.

4. Enter data specific to Goals. Once the data described in step 2 are collected for the current year and decisions are made about funding options and adapting the model to the activities in the strategic plan, the data are entered into the Goals model.

5. Conduct resource allocation workshops. In most applications the model will be used in a workshop with decision makers. The workshop will be an interactive session where participants will try out different resource allocation strategies and observe the consequences. Participants may use the model to examine different types of issues, such as "Which prevention interventions are most cost-effective?" "How many people are receiving palliative care with the current allocation?" "How many people can be treated with ART with available funds? How would that change if drug prices were lower?" As various options are tested with the model the participants will gain a better understanding of the trade-offs involved and the amount of funding required to achieve the goals.

6. Follow-up on workshop outcomes. A variety of workshop outcomes are possible. Ideally the model is applied as part of the overall strategic planning process. In this case the model may continue to be used as goals are revised and funding plans are developed. The workshop may result in a new budget for the plan, or a commitment to raise additional funds to pay for essential programs. Reports and presentations may need to be prepared in order to disseminate the results to national decision makers, donors and program partners.

7.5.4   Goals input editors

7.5.4.1   Configuration

You need to provide values for those inputs that are required to estimate the impact of prevention interventions. These include the "Base year of coverage", the "Secondary school enrollment rate" and the "Percent of adults in formal sector employment". "Base year of coverage" can be found on the Goals configuration editor, while "Secondary school enrollment rate" and "Percent of adults in formal sector employment" are found on the General Population tab of the Population sizes editor in the Resource Needs Module.

- **Base year of coverage**: You directly enter key behaviors (condom use, number of partners, age at first sex, needle sharing) for all years up to and including the 'Base year of coverage'. These behaviors will be calculated for all years after the 'Base year of coverage' based on intervention coverage and impact. Thus, you should usually set this to be the current year or the last year for which you have coverage data for behavioral interventions (condom promotion, outreach, VCT, etc.)

- **Number of MSM risk groups:** For most applications this should be set to 'One group'. However, if you have enough information you can divide the MSM group into four activity groups based on the frequency of partner change: Low, Medium, High and MSM/IDU.

- **Secondary school enrollment**: The percentage of children of secondary school age enrolled in secondary school. This is used to determine the impact of population eligible for school-based AIDS education.

- **Percent of adults in formal sector employment**: The percentage of all adults 15-49 who are employed in the formal sector. This is used to determine the population potentially reachable through work place prevention programs.

7.5.4.2 Epidemiology

7.5.4.2.1 Epidemiology

Under the **Epidemiology** tab, you can review and set the key epidemiological parameter values. In many cases you can accept the default values provided. More detail on the source of these values is available in the Method section of the Goals Manual.

You should set the "Epidemic Start Year" to the first year of the epidemic. This is the first year when prevalence is significantly larger than zero. Often this can be approximated by 2-3 years before first AIDS case report.

7.5.4.2.2 HIV prevalence

Under the **HIV prevalence** tab you can enter any survey or surveillance data available on HIV prevalence in the different risk groups. For example if you have a national household survey that measured HIV prevalence you would be able to enter values for that year for "Total Males", "Total Females", and "Adults". You should only enter data for the years in which it was measured. You do not need to interpolate to fill in intervening years. Zeros in this editor are equivalent to "No Data". The data you enter here are used to compare against the model results in order to see how the model fits the actual data. These data are not used in the model calculations.

7.5.4.2.3 STI prevalence

Under the **STI prevalence** tab you can enter information on the prevalence of STIs (sexually transmitted infections). Unlike the data on HIV prevalence, the data on STI prevalence are used in the calculations. Therefore you must enter data for all years and all risk groups. The presence of STIs increases the probability of HIV transmission.

7.5.4.2.4 Blood transfusion

Under the **Blood transfusion** tab you can enter information on the number of people infected with HIV through contaminated blood transfusions. In most countries this accounts for only a small portion of new infections and, therefore, this section can be ignored. However, in a few countries this has been a key source of new infection and should be addressed here.

7.5.4.3 Behavior

7.5.4.3.1 Behavior

Behavior

Here you specify the distribution of the population by risk group. For both males and females the risk group proportions must sum to 100.0. Information on the sizes of risk groups may be available from national surveys, behavioral surveillance surveys, or other size estimation activities. This information is available for most countries since it is used in preparing national prevalence estimates. A summary is provided below.

Estimates of population sizes by region

(MSM and clients as % of male pop; FSW as % of female pop)

Men having sex with men		High risk	Injecting drug users	
E. Asia	3 – 5%	<2.8%	E. Europe and C. Asia	0.06 – 5.21%
S & SE Asia	6 – 12%	1.2-7.2%	Asia and the Pacific	0.021 – 1.33%
E. Europe	6 – 15%	1-5.5%	M East, N. Africa and	
			sub-Saharan Africa	0.05 – 2.07%
Latin America	6 – 20%	0.8-4.8%	Latin America & Caribbean	0.29 – 1.15%

Female sex workers		Clients of sex workers	
Sub-Saharan Africa	0.4 – 4.3%	All	9 – 10%
Asia	0.2 – 2.6%	Central Africa	13 – 15%
Russian Federation	0.1 – 1.5%	Eastern and southern Africa	10 – 11%
E. Europe	0.4 – 1.4%	Asia	5 – 7%
W. Europe	0.1 – 1.4%	Latin America	5 – 7%
Latin America	0.2 – 7.4%		

Source: Sexually Transmitted Infections, 2006 Jun; 82 (suppl)3; Mathers B et al Lancet 2008, 372:1733-1745.

Average duration of behavior (years)

Also in this editor you specify the average time spent in the risk group. For most risk groups the duration will be "Lifetime". However, for some risk groups, most notably "Female high risk" duration in the risk group is usually only 2-10 years. In these cases you should click the radio button next to the box and enter the average number of years in the risk group in the box. The table below summarizes information on time in risk group from a number of studies.

Estimates of time in most-at-risk populations by region

Average duration of female sex work, by region

Region	Duration of behavior in years
Africa	5.5 (4 studies)
Asia/Oceania	2.9 (12 studies)
North America	10.2 to 11.0 (3 studies)
Europe	8.4 to 10.0 (10 studies)
Latin America	11.2 to 12.0 (6 studies)

Average duration of injecting drug use, by region

Region	Duration of behavior in years
Africa	5.6 (1 study)
Asia	8.7 (6 studies)
Oceania	17 (1 study)
Europe	13.9 (1 study)
North America	9.5 (1 study)
South America	21 or 19.6 (9 studies)

Source: Fazito E et al. Forthcoming

7.5.4.3.2 Injecting drug user

In this editor you enter the percent of IDU that share needles and the force of infection for male and female IDU. The force of infection is used to determine the spread of HIV among IDU. The value can vary between 0 and 1. There is no direct way to determine this input. You need to try different values and examine the resulting IDU prevalence curves to determine the correct values. Typical values in countries with serious HIV epidemics among IDU start at 0.35 – 0.50 and usually decline with time as the highest risk population becomes infected first.

7.5.4.3.3 Condom use

In this editor you enter the proportion of sex acts in each risk group in which condoms are used. You have two options for specifying condom use: "Use interpolated values" requires you to enter values for each year of the analysis while "Use logistics curve" allows you to create curves to describe the changes in condom use over time. The curves are displayed in the lower portion of the screen. The parameters of the curves are:

- **Initial value.** Condom use at the beginning of the epidemic. Usually this is nearly zero.

- **Final value.** The percentage of acts covered by condom use today.

- **Growth rate.** The speed at which condom use increased from the initial value to the final value. The higher the value the more quickly the transition happens. Typical values would be between 0.5 – 0.8.

- **Growth location.** The parameter determines when most of the change took place. A low value, such as 0.1, will cause the growth to be recent, a higher value, such as 0.9, will cause it to start earlier.

- **Years to final value.** The number of years it takes to get from the initial value in the first year of the projection to the final value today. This determines when the curve stabilizes at the final value.

7.5.4.3.4 Number of partners

The average number of different sexual partners per year for each risk group. This is generally 1 for low risk groups and higher for the medium and high risk populations.

7.5.4.3.5 Sex acts per partner

The number of sex acts per partner per year. Note that this is not the total number of sex acts per year but the number of acts per partner. For low risk populations, with one partner, it will be the same as the number of sex acts per year. For groups with more than one partner the number of sex acts per year will be the average number of partners multiplied by the number of acts per partner. The number of sex acts and partners should be balanced within risk groups. Thus, within the medium and high risk populations the total number of sex acts for men and women should be the same. The total number of sex acts is the number of partners multiplied by the number of acts per partner multiplied by the proportion of the population in the risk group.

7.5.4.3.6 Age at first sex

The average age at first sex. This is usually available from national household surveys such as Demographic and Health Surveys.

7.5.4.3.7 Increased recruitment

The proportion of those becoming sexually active who enter each risk group is initially determined by the proportion of the total population in that risk group. However, since those in the highest risk groups will have higher mortality than those in the lowest risk groups, the proportion of the population in the high risk groups will decline over time. In some cases, when the high risk behavior is defined by an occupation, such as a sex worker, truck driver or miner, new people will be recruited to replace anyone who dies from AIDS. Thus the proportion in these risk groups may not decline over time due to replacement. In this editor you can specify the proportion of mortality that is replaced by more recruitment into the high risk population group.

7.5.4.3.8 Percent married

In this editor you specify the proportion of those in each risk group that are married or in a long term union. For the low risk population this will be 1.0. For higher risk populations it will usually be less than one but not zero.

7.5.4.4 Coverage

In the **Coverage** tab you specify the coverage of each intervention, where coverage is the percentage of the eligible population reached by the intervention. The first year of the editor is the year you specified in the Configuration editor as the "Base year of coverage". The impact of these interventions on the key behaviors is determined by the increase in coverage from the first year. If coverage is constant then behaviors will not change from the base year.

7.5.4.4.1 General population

See General population coverage for RNM.

7.5.4.4.2 Most-at-risk populations

See Most-at-risk populations coverage for RNM.

7.5.4.4.3 Medical services

See Medical services coverage for RNM.

7.5.4.4.4 Male circumcision

In this editor you enter the proportion of males that are circumcised. This figure is usually constant from the first year of the projection until 2010 and then may change after 2010 if there is a program to expand medical male circumcision.

See Male circumcision coverage for RNM.

7.5.4.4.5 PrEP

Pre-exposure Prophylaxis (PrEP)

Pre-exposure prophylaxis refers to drugs take by uninfected individuals to reduce the chance of becoming infected with HIV. The four products included in the Goals model are:

- **Oral PrEP:** A once daily pill taken orally containing either tenofovir disoproxil fumarate (TDF) or a combination pill with both TDF and emtricitabine. In 2011 two trials, Partners PrEP and CDC TDF2, demonstrated effectiveness of oral PrEP in preventing HIV transmission in heterosexual contact. Earlier the iPrEx study showed the effectiveness of oral PrEP in men who have sex with men.

- **Gel:** Drugs to prevent HIV infection may also be administered to women as vaginal gels. The CAPRISA 004 trial showed efficacy of tenofovir gel in preventing HIV in women but the VOICE trial did not find evidence of effectiveness. These gels are also known as microbicides.

- **Ring:** Research is underway to develop a vaginal ring for women, similar to the contraceptive ring, which would release prophylactic drugs over time.

- **Injectable:** A key finding from PrEP studies to date is that effectiveness is very dependent on adherence. Low levels of adherence have been seen in trials of oral PrEP, reducing its effectiveness. Research is underway to develop an injectable form of PrEP that might provide protection for one month or longer.

The implementation of PrEP in Goals involves three sets of inputs.

- **Coverage:** Coverage refers to the percentage of the population using any form of PrEP. Coverage is specified by sex, risk group and year. Coverage should be zero until the year a product first becomes available. Coverage can be zero in some groups and not in others. For example, to simulate a PrEP program for MSM coverage among MSM could be set to some target value, say 30%, while coverage in all other groups remains at zero. If more than one product is implemented then coverage is the combined percentage of the population using any of the products.

- **Method mix:** Method mix describes the distribution of PrEP users by product. It should always sum to 100%. The mix can change with time. For example, if oral PrEP were introduced in 2014 then the method mix would show 100% for oral PrEP and zero for injectable, gel and ring. If a gel is introduced later, in 2017 for example, then the method mix might be 50% oral and 50% gel for women. For men it would remain 100% oral. You can access the method mix editor for any risk group by double clicking on the name of the risk group.

- **Effectiveness:** Effectiveness is a combination of two inputs: efficacy and adherence. Efficacy refers to the reduction in the chance of becoming infected given perfect use. Adherence refers to the proportion of users that practice recommended use. The combination of the two factors is the effectiveness of PrEP in reducing the probability of becoming infected.

Goals contains default distributions for method mix based on current thinking about dates of introduction. You can use these default patterns and just enter coverage by sex and risk group. If you want to change the method mix for any risk group, double click on the name of the risk group. That will cause an editor to appear allowing you to change the method mix.

If you want to apply the same coverage, method mix and effectiveness assumptions to several different Spectrum projections you can do that with the "Read from file" option. This option allows you to read all the coverage, method mix and effectiveness information from a text file save in the CSV format (an Excel format). This file needs to be in a specific format. You can create a PrEP coverage file easily by first filling

in all the information in the PrEP editor and then selected "Save to CSV file". This will write the information in the PrEP editor to a file which you can then read into other Spectrum projections.

7.5.4.4.6 Vaccines

If you want to consider the potential impact of future vaccines you can specific the efficacy, target population, mode of action and coverage in the Vaccine editor.

7.5.4.4.7 Treatment

Eligibility for treatment

Enter the CD4 count threshold that defines eligibility for treatment by year.

ART Coverage

The Antiretorviral therapy editor is used to enter ART coverage. This can be done by entering a number/percent for each year or by entering the CD4 count for each category for each year.

If you opt to use number/percent you would enter either the number of adults receiving ART by year or the coverage of ART (the percentage of those eligible receiving treatment). Typically you would enter the number on ART for the historical period and either numbers or percentages for the future. Do not enter both numbers and percents in the same year. The entry on migration from first to second line is the proportion of those on first line ARVs moving to second line regimens each year. This is used only for the calculation of the costs of treatment.

See [Treatment coverage for RNM](#).

7.5.4.5 Impact matrix

In the **Impact matrix** tab you can view and change any of the values in the impact matrix.

The impact of behavior change is expressed in the transmission equation by the variables for condom use Cc, and the number of partners B. Behavior change interventions can also affect age at first sex, which determines when people become sexually active, and needle sharing among IDUs, which determines the proportion of injecting drug users that is susceptible to infection.

The impact of interventions on each of these behaviors is determined by an impact matrix that describes the impact of each intervention on each behavior for each risk group. The impact matrix is based on an extensive literature search and describes behavior changes for each behavior and each risk group.

For condoms, impact is calculated as a reduction in the non-use of condoms in order to allow for the aggregation of impacts when several interventions are present. Thus, condom use is calculated as one minus the non-use of condoms in the base year multiplied by the product across all interventions of the increase in coverage of each intervention and its impact on condom non-use.

$$Cc_t = 1 - (1 - Cc_o) \times \prod_i (Coverage_{i,t} - Coverage_{i,0}) \times CondomImpact_i$$

The impact on the number of sexual partners is determined as the number of partners in the base year multiplied by the product of the increase in coverage and the impact of each intervention.

$$n_t = n_0 \times \prod_i (\text{Coverage}_{i,t} - \text{Coverage}_{i,0}) \times \text{Number of Partners Impact}_i$$

The impact on age at first sex is calculated as age at first sex in the base year multiplied by the product of the increase in coverage and the impact of each intervention.

$$AFS_t = AFS_o \times \prod_i (\text{Coverage}_{i,t} - \text{Coverage}_{i,0}) \times \text{Age at First Sex Impact}_i$$

Similarly the impact on needle sharing is calculated as the proportion sharing needles in the base year multiplied by the product of the increase in coverage and the impact of each intervention.

$$NS_t = NS_o \times \prod_i (\text{Coverage}_{i,t} - \text{Coverage}_{i,0}) \times \text{Needle Sharing Impact}_i$$

7.5.4.6   Unit costs

7.5.4.6.1 General population

See General population unit costs for RNM.

7.5.4.6.2 Most-at-risk populations

See Most-at-risk populations unit costs for RNM.

7.5.4.6.3 Medical services

See Medical services unit costs for RNM.

7.5.4.6.4 Male circumcision

See Male circumcision unit costs for RNM.

7.5.4.6.5 PrEP

7.5.4.6.6 Vaccines

7.5.4.6.7 PMTCT

See PMTCT unit costs for RNM.

7.5.4.6.8 Treatment

See Treatment unit costs for RNM.

7.5.5   Fitting the epidemic

Once all the inputs have been entered in Goals you need to fit the model to the epidemic. This involves comparing the model output to the surveillance and survey data and, if necessary, adjusting some of the inputs to better match available data. You can easily compare the model results to available data using the **Model fitting** selection under the **Results** menu. When you select this option you will see a display like the following:

This display compares adult HIV prevalence as estimated by Goals in the red line, to the data on prevalence that you entered into the HIV prevalence tab of the Epidemiology editor, shown with the triangles. This particular display shows prevalence among all adults, but you can also display prevalence for any risk group by making an appropriate selection under Configure. Note that you can also examine trends in prevalence for all risk groups at once by selecting "Results – Current Infections – Prevalence all risk groups".

If the model does not fit the data well there are a number of changes that you can make to improve the fit.

- **Size of initial pulse of infection**. A larger or smaller value will provide a faster or slower start to the epidemic.

- **Epidemic start year**. Changes will allow the epidemic to start earlier or later.

- **Transmission of HIV per act (female to male)**. A larger value will raise the entire prevalence curve while a smaller value will produce lower prevalence.

- **Primary infection**. A larger value will raise the prevalence curve while a smaller value will reduce it.

- **STI prevalence**. The pattern of decline in STI prevalence will affect the shape of the prevalence curve.

- **IDU force of infection**. To fit the IDU prevalence trend, adjust the male and female force of infection in the Behavior - IDU editor.

- **Condom use**. Changing the trend in condom use will change the shape of the prevalence curve.

- **Number of partners**. Raising the number of partners for medium or high risk groups will increase prevalence among those groups.

- **Acts per partner**. Raising the values will increase prevalence. Coital frequency among low risk population is usually measured at 60 – 110 acts per year. Since recent data on coital frequency are often lacking you may wish to try different values in this range to adjust prevalence among the low risk population.

- **Percent married**. Higher values of percent married will produce higher prevalence in the low risk population and low values will produce lower prevalence in the low risk group.

7.5.6   Creating scenarios

Once your model is fit you can use it to examine alternative future programs. Start by opening your base Goals file if it is not already open. Then use **File -> Open** to open the base Goals file again. When you do this Spectrum will recognize that you are opening the same file twice. You will see the message:

SPECTRUM.exe

?   Projection is already loaded, what would you like to do?

[Load anyway]   [Load and rename]   [Cancel]
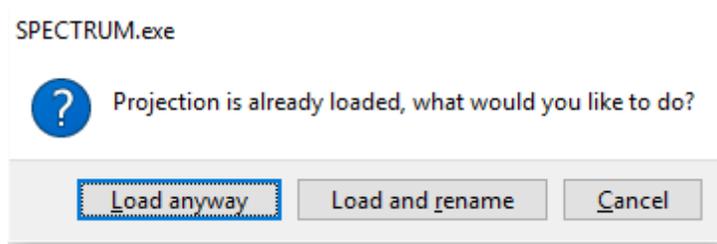
Click 'Load and rename' and then provide a name for this scenario, such as 'NSP'. Then you will have two files open that are exactly the same. You can modify the coverage targets in one scenario and leave the base Goals file unchanged. Then you can easily compare the results of the new scenario with the base case.

When both files are open the names will appear at the bottom of the Spectrum window. One name will be in **bold** type. That is the scenario that will be changed when you edit the inputs. To edit the other projection just click on the name and it will become **bold**.

You can use the Goals model to estimate the cost and impact of your national strategic plan or other targets, such as Fast-Track. To do this you just need to enter the NSP targets in the **Coverage** editor. In most cases you can enter the target for the final year of the plan and then interpolate from the base year to fill in the intervening years and duplicate the target values for all years beyond the target year.

If you wanted to calculate the cost and impact of achieving the Fast-Track targets you would enter the following coverage target for 2020 and 2030 and fill in the intervening years with interpolation:

Intervention	2020 Fast-Track Target	2030 Fast-Track Target
General population		
Condom promotion	90%	90%

Cash transfers for young women and girls (15-24)	30%	30%
Most-at-risk populations		
Services for sex workers	90%	90%
Services for MSM	90%	90%
Services for PWID	90%	90%
Opioid substitution therapy	40%	40%
Voluntary medical male circumcision	90%	90%
PrEP	10%	30%
ART (Coverage among all PLHIV)	81%	90%

Once the coverage targets are set, save your file under a new name, such as COUNTRY_NSP. Then use **File -> Open** to open your original file. Then you will have two files open, one with constant coverage and one with the targets. When you display results you will be able to see both projections.

1. Use **AIM -> Results** to see the number of new infections, AIDS deaths, people living with HIV and other indicators.

2. Use **RNM -> Results** to see the resources required and the number of services provided.

7.5.7   Cost-effectiveness

Goals has a special tool, called **Cost-Effectiveness Analysis (CEA)**, for calculating the cost-effectiveness of each intervention. To use this tool, select **Tools** from the top horizontal menu, then **More Tools** and **Cost-Effectiveness Analysis**. You can set the target year (the year by which the coverage targets will be reached) and the discount rate. In the 'Target Year' column enter the coverage targets. These can be the same as your Strategic Plan or Fast-Track Targets. Enter targets only for those intervention you want to analyze. The others can remain blank. The second column shows the coverage in the base year.

Once you have entered all the targets click the **Process** button and the analysis will start. The tool will examine each intervention one-at-a-time. It will scale-up the coverage as indicated and record the number of infections averted (compared to a base intervention with no scale-up of any interventions) as well as the number of deaths and DALYs averted and the incremental cost. Once all interventions are done the tool will display a table with the results. You can click on the **Display Chart** button to see the result in graphical form. The chart, shown below, displays the total infections averted by the intervention on the horizontal axis and the cost per infection averted on the vertical axis.

Impact and cost-effectiveness in United Republic of Tanzania
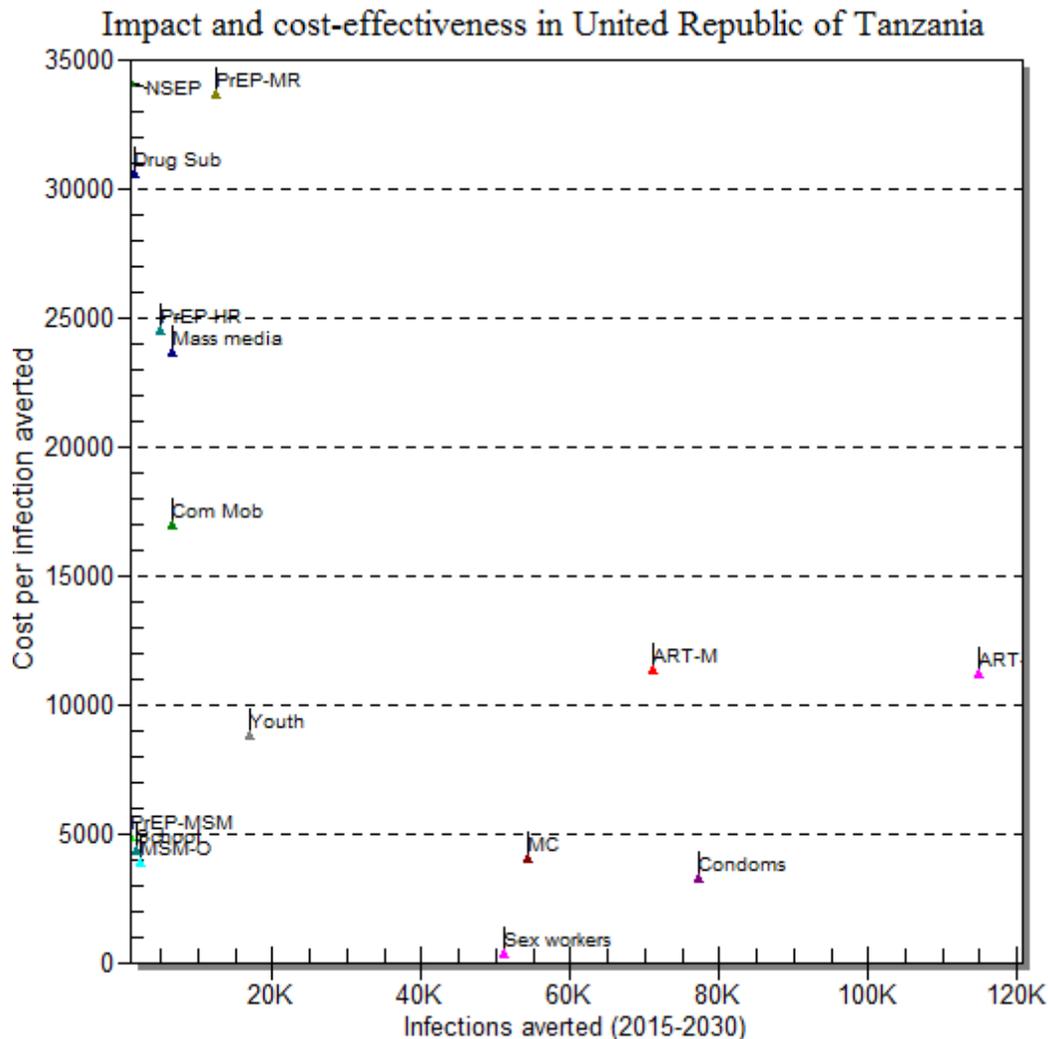
The 'best' interventions are those that avert many infections and do not cost very much. These are in the lower right quadrant of the chart. Those that are expensive and have little impact will be in the upper left quadrant.

This tool can give you an idea of the relative ranking of the intervention by total impact and cost-effectiveness. Note that since each intervention is scale-up individually in this analysis the total impact of a combination of intervention will be less than the sum of individual impacts.

7.5.8   Optimization

An important question to ask when planning your response is 'How can we get the greatest impact for the funds we expect to have available?' The **Optimize** tool can help with that question.

To use the **Optimize** tool select **Tools**, **More Tools** and **Optimize.** (Note that you can only access the tool when just one projection is open. If you have more than one projection open, you will need to close all but one before you can use this tool.) Once you start the tool the screen will look something like this:

Optimize   —   □   ✕

Start year   Target year   Final year

| 2016 ∨ | 2020 ∨ | 2030 ∨ |

Discount rate (%)   Goal

| 3 | New infections ∨ |

Intervention	Current coverage	Minimum	Maximum		Year	Funding available
ART	40.40	40.40	81.00		2016	956,670,118
VMMC	72.30	72.30	90.00		2017	825,484,817
Condom promotion	44.00	44.00	90.00		2018	864,546,489
Sex worker outreach	11.00	11.00	90.00		2019	904,961,289
MSM outreach	40.00	40.00	90.00		2020	1,164,180,827
PWID outreach	20.00	20.00	20.00		2021	1,144,257,517
PWID N&SEP	13.00	13.00	90.00		2022	1,151,056,321
PWID OST	6.00	6.00	40.00		2023	1,158,150,507
PrEP: adolescents	0.00	0.00	10.00		2024	1,165,576,523
PrEP: SW	0.00	0.00	10.00		2025	1,173,474,173
PrEP: MSM	0.00	0.00	10.00		2026	1,181,792,511
Community mobilization	21.80	21.80	80.00		2027	1,190,734,166
Media communications	55.00	55.00	80.00		2028	1,200,187,505
Youth in school	80.00	80.00	100.00		2029	1,210,203,290
Youth out of school	25.00	25.00	50.00		2030	1,220,860,304
Cash transfers	0.00	0.00	30.00			

| Close | Process |

By default the first year of the optimization is set to 2016, the target year for coverage is 2020 and the final year of the analysis is 2030. You can change those years if you want. The Goal can be set to minimize new infections, AIDS deaths or DALYs. The first table shows the current coverage for each intervention plus the minimum and the maximum. By default, the minimum coverage is set to the current coverage and the maximum is set to Fast-Track goals, but you can change these. Setting the minimum coverage below the current coverage means that resources can be taken away from that intervention and allocated elsewhere, if that is cost-effective.

The second table shows the total funding that you expect to be available in the future. Initially this will be all zeros. You need to fill it in with an estimated funding stream. Once all the inputs set press the **Process** button.

The **Optimize** tool will first run a cost-effectiveness analysis using the CEA tool described above. From that analysis it will prepare a rank ordered list of interventions by cost-effectiveness. To determine an

optimum allocation of the available funds, the tool will implement the most cost-effective intervention first, then move to the next most cost-effective intervention, and continue in this manner until all the available funding in that year is used up. Usually the last intervention to be implemented will be partially scaled-up because there will not be enough funds left to fully implement it.

Once the analysis is complete you will see a message showing you the all the interventions that were implemented even partially in some years. Any interventions not shown on the list were not implemented with the available funding.

Click **Close** and **Close** again to return to the main Spectrum page. The optimized projection will be automatically opened. It will have the same name as your original projection with '_Optimized' added to the end. You can then view any of the indicators, such as new infections shown below, and see the impact compared to the base case.

Number of new HIV infections
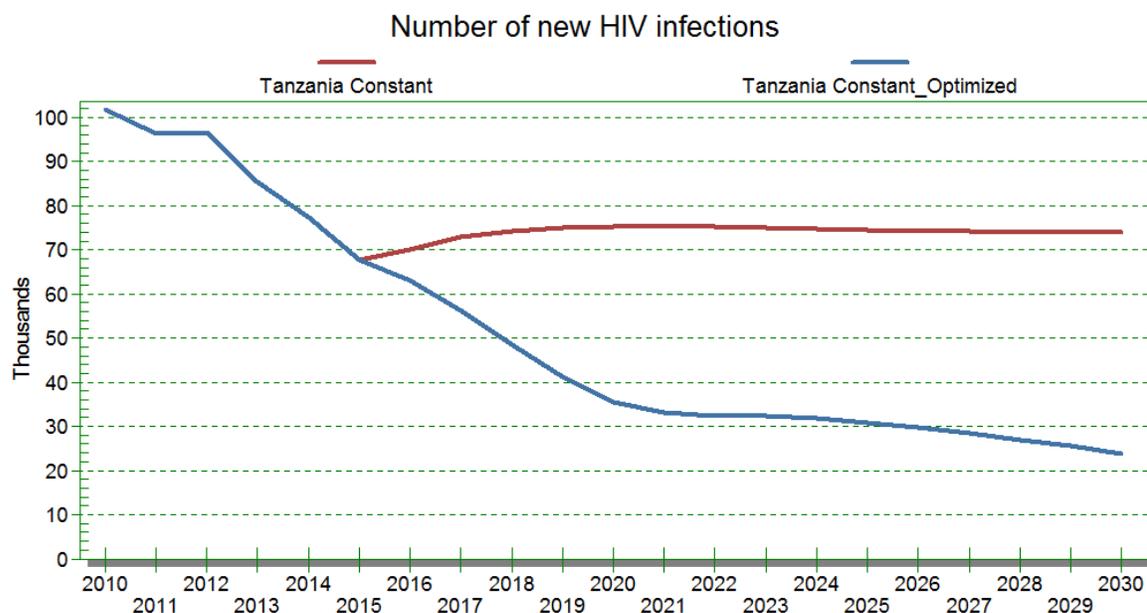
To see which interventions were scaled-up and which were not, look at the **Coverage** editor.

Note that this is a basic optimization that assumes that an optimum mix of interventions can be determined using cost-effectiveness measures calculated by scaling up each intervention one-at-a-time. A more comprehensive approach would test all combinations of interventions and all scale-up amounts, or use a sophisticated optimization algorithm to search for an optimum combination. Such an analysis can take a long time to run and, in practice, the results are not usually very different from this more basic approach. If there is quite a bit of separation between the interventions on the cost-effectiveness chart, shown on page 4, then this basic approach should be fine. However, it may not distinguish well between interventions that have nearly the same cost-effectiveness.

A second limitation is that the Goals model allows unit costs to vary with time but not as a function of coverage. It may be that unit costs should decline with scale and/or rise at very high coverage levels. If so, then some interventions might become less cost-effective when coverage levels are high. However, very little information exists on the relationships between cost and national coverage so this relationship is not included in this tool.

The purpose of the **Optimize** tool is to provide information on two key aspects of strategic planning:

- How much impact can we expect to get from rational allocation of available funding?

- Which interventions should be scaled-up to get the most impact from available funding?

The results from this tool can inform discussions as plans are developed.

7.5.9   Evaluating historical impact

You can also use Goals to estimate the expected impact of program accomplishments to date. In this case instead of modifying future intervention coverage you will modify the past. You can do this with any input to Goals, but the most useful are:

- **ART**. Create a new scenario and call it NO_ART. Go to **Modules -> AIM -> Program statistics -> Adult ART** and set all entries to zero. Then click OK and display the results under **Results -> Total population -> New infections** or **AIDS deaths**. The difference between the No_ART scenario and the base Goals projection is the impact of ART.

- **PMTCT**. Create a new scenario called NO_PMTCT and set all PMTCT entries to zero. Compare the number of new child infections with and without PMTCT.

- **VMMC**. If the VMMC program has increased the coverage of male circumcision in your country, you can estimate the impact by editing the coverage of male circumcision (under **Goals -> Coverage -> Male circumcision**) and setting coverage to be constant from 2007 (before the start of VMMC programs) until the end of the projection. Compare the number of new infections with the base projection.

- **Condom use**. Change condom use (under **Goals -> Behavior -> Condom use**) to be constant from 1990 onwards. If the condom editor is set to **Use logistics curve** just change the radio button selection to **Use interpolated values**. Then you will be able to edit the condom use rates directly.

You can also create a scenario with all of these changed at once to examine the total impact of the program. Then compare the new infections or AIDS deaths in the base file with the new scenario, as shown below.

Number of new HIV infections
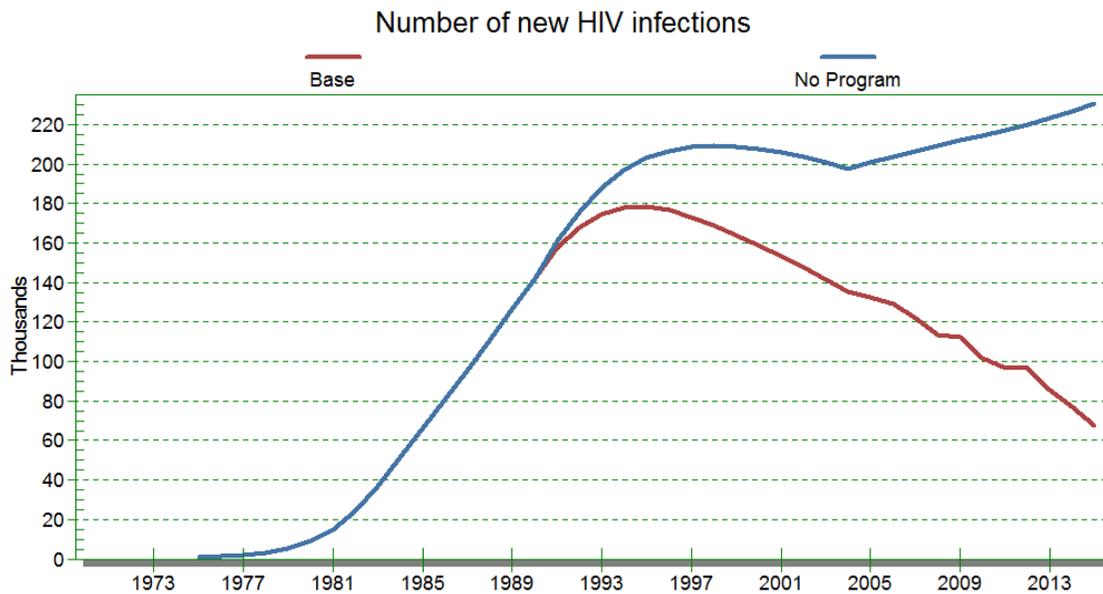
In the chart above the difference is quite large. You would need to run separate scenarios for each intervention to see how much of the impact is due to each intervention. To determine if the difference is significant you can use the uncertainty bounds around the AIM estimate. For example, if the official AIM estimate for 2015 has a range of +/- 20,000 and the difference between the Base and No Program scenarios is 160,000 you can be confident that there was a significant impact.

7.5.10 Methodology

7.5.10.1 Introduction

The Goals model is intended to support national and international planning for HIV programs by projecting the expected impact and cost of combinations of prevention and treatment programs. It contains a transmission model that calculates the number of new HIV infections over time as a result of sexual and injecting drug transmission. It links to the AIM model to also calculate new child infections due to mother-to-child transmission. Goals can be used to investigate the impact and cost of scaling up different interventions at different rates. The model is intended to support planning efforts by providing information to answer key questions such as:

- How much can we reduce the number of new infections by scaling up a defined package of interventions?

- How much will it cost?

- What goals can be achieved with expected resources?

- How would alternate patterns of resource allocation affect the impact and cost?

- What is the expected impact of new methods of HIV prevention such as pre-exposure prophylaxis (PrEP) or vaccines?

The Goals model is implemented as a module within the Spectrum model. It interacts with other modules in Spectrum. The demographic projection module, DemProj, performs demographic calculations and provides information on the size of the adult population and the number of people becoming adults, aging out of the 15-49 age group and dying from non-AIDS causes. The AIM module uses incidence as calculated by Goals to project the additional indicators such as new child infections due to mother-to-child transmission.

7.5.10.2 Structure

The Goals model simulates an HIV epidemic in an adult population aged 15-49. The focus is on this population because most new infections occur in this age group and most survey data on sexual behavior refer to this age group. The adult population is disaggregated by sex and risk group. People enter the model at age 15 and are assumed to not be sexually active until they reach the median age at first sex. Then they are allocated to one of the five risk groups, as shown in Figure 1. The categories were chosen because they are epidemiologically important and information on the proportion of population in the three of the categories (stable couples, multiple partners and sex worker and clients) is available from national surveys.

The risk groups are defined by the behaviors specified in each application, so almost any risk structure might be modeled. However, in practice the standard risk groups are those shown in Figure 1. *Stable couples* are men and women reporting a single partner in the last year. The *multiple partner* category refers to those who report more than one partner in the last year but are not in any of the higher risk categories. *Sex workers and clients* refers to female sex workers and male clients. *MSM* refers to men who have sex with men. *IDU* refers to injecting drug users. While any individual may belong to more than one group, people are classified according to their highest risk.

Figure 1. Risk Structure of Goals
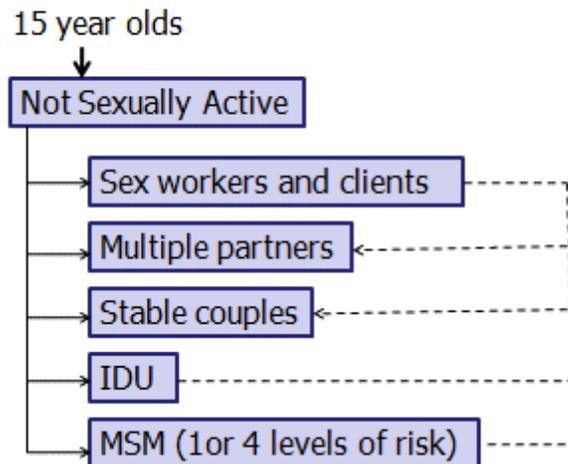
Once a person joins a risk group he or she remains in that risk group until aging out at age 50, dying from non-AIDS cases, dying from AIDS or changing behavior. Behavior change allows people to move from one risk group to a lower risk group. Duration in a risk group may be specified as lifetime or as an average number of years. For example, duration in sex work might be set to 5 or 10 years. Those leaving the highest risk groups (sex work, MSM, IDU) move to the medium risk group (casual sex) and those leaving the casual sex group move to the stable couples risk group.

7.5.10.3 Sexual transmission of HIV

Transmission of HIV from an infected partner to an uninfected partner depends on the characteristics of both partners and the partnership, as shown in Figure 2. For the susceptible partner the important characteristics are the number of partners, if male whether he is circumcised, and whether or not new prevention methods, such as PrEP or vaccines, are used. Transmission from the infected partner is affected by the stage of infection (primary, asymptomatic, or symptomatic), whether the partner is receiving ART and whether the partner has been vaccinated with an HIV vaccine that reduces infectiousness. Characteristics of the partnership that influence transmission are the number of acts per partner per year, whether either partner has a sexually transmitted infection, the type of contact (heterosexual, MSM or needle sharing) and condom use.

Figure 2. Characteristics determining transmission of HIV
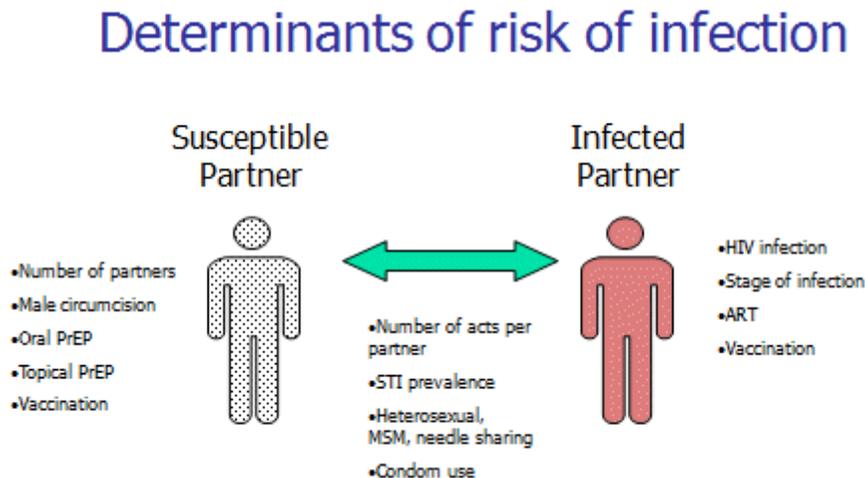
New infections, I, are calculated as the susceptible population, X multiplied by the probability of becoming infected, t.

$$I_{s,k,t} = X_{s,k,t} \times t_{s,k,t}$$

Where

s	= Sex, male or female
k	= Risk group
t	= Time

The probability of transmission to an uninfected partner during one year, t, is given by the equation below.

$$1 - \left[P_{s',k,t} \times \left(1 - r \times R_t \times MC_{k,t} \times C_{k,t} \times V_{k,t} \times S_{k,t} \times \text{Pr}_{k,t}\right)^a + \left(1 - P_{s',k,t}\right) \right]^n$$

Where

$P_{s',k,t}$	= HIV prevalence in the partner population of risk group k at time t
r	= Base probability of HIV transmission per act
R_t	= Multiplier for the effect of stage of infection

$C_{k,t}$	= Multiplier for effect of condom use
$MC_{k,t}$	= Multiplier for effect of male circumcision
$S_{k,t}$	= Multiplier for effect of sexually transmitted infections
$Pr_{k,t}$	= Multiplier for effect of PrEP
$V_{k,t}$	= Multiplier for effect of HIV vaccines
a	= Number of acts per partner per year
n	= Number of partners per year

Prevalence in the partner population is defined differently for each risk group. For sex workers or clients and those with multiple partners, it is the prevalence of the population of the opposite sex in the same risk group. For MSM it is the prevalence in the MSM group. For stable couples the prevalence in the partner population is a weighted average of the prevalence in each risk group P multiplied by the proportion of contacts with that risk group A.

$$P_{s,k,t} = \sum_k P_{s',k,t} \times A_{s,k,t}$$

For those in stable relationships the proportion of contacts with each risk group is calculated from the number of people in each risk group N_k and the proportion married m.

$$A_{s,k,t} = \sum_k m_{s,k} \times N_{s,k,t} \div \sum_k N_{s,k,t}$$

The effect of stage of infection is calculated as a weighted average of infectiousness by stage i and the proportion of the population in each stage.

$$R_t = \sum_i \sum_k \sum_s Y_{i,k,s,t} \times IM_i \div \sum_i \sum_k \sum_s Y_{i,k,s,t}$$

Where

$Y_{i,k,s,t}$	= HIV+ population in stage i risk group k sex s at time t.
IM_i	= Infectiousness multiplier of stage i

The stages are primary infection, asymptomatic, symptomatic (CD4 count < 200 cells/µl) and on ART.

The impact of sexually transmitted infections (STIs) is calculated from the prevalence of STIs in either partner and the increase in transmission when STIs are present.

$$S_{k,t} = 1 + Sm \times Sp_{k,t}$$

Where

Sm	= Multiplier on the probability of transmission when either partner has an STI

$Sp_{k,t}$ = Proportion of risk group k with an STI at time t

7.5.10.4 Transmission among injecting drug users

The probability of transmission through drug injections is determined by a force of infection variable that expresses the rate of contact between sharing groups, f, the prevalence of HIV among IDU, P, the multiplier for stage of infection, R, and any effects of new technologies such as vaccines, V or PrEP, Pr.

$$f_t \times P_{k,t} \times R_t \times \mathrm{Pr}_{k,t} \times V_{k,t}$$

7.5.10.5 Impact of biomedical interventions

The impacts of biomedical interventions are included in the transmission equation by the multipliers for condoms, C, male circumcision, MC, PrEP, Pr, and vaccines, V. The calculation of each multiplier follows the same form, (1 – effectiveness) multiplied by the percentage of the population covered.

$$C_{k,t} = 1 - Ce \times Cc_{k,t}$$

Where
- Ce = Condom effectiveness
- $Cc_{k,t}$ = Proportion of risk group k using condoms at time t

Similarly,

$$MC_{k,t} = 1 - MCe \times MCc_{k,t}$$
$$\mathrm{Pr}_{k,t} = 1 - \mathrm{Pr}e \times \mathrm{Pr}c_{k,t}$$
$$V_{k,t} = 1 - Ve \times Vc_{k,t}$$

7.5.10.6 Impact of behavior change interventions

The impact of behavior change is expressed in the transmission equation by the variables for condom use, Cc, and the number of partners, n. Behavior change interventions can also affect age at first sex, which determines when people become sexually active, and needle sharing among IDUs, which determined the proportion of injecting drug users that is susceptible to infection.

The impact of interventions on each of these behaviors is determined by an impact matrix that describes the impact of each intervention on each behavior for each risk group. The impact matrix is based on an extensive literature search which is described in detail elsewhere[1].

The impact matrix describes behavior changes for each behavior and each risk group as shown in Tables 1-4 below.

For condoms, Table 1, impact is calculated as a reduction in the non-use of condoms in order to allow for the aggregation of impacts when several interventions are present. Thus, condom use is calculated as one minus the non-use of condoms in the base year multiplied by the product across all interventions of the increase in coverage of each intervention and it impact on condom non-use:

$$Cc_t = 1 - (1 - Cc_o) \times \prod_i (Coverage_{i,t} - Coverage_{i,0}) \times CondomImpact_i$$

Table 1. Reduction in Non-Use of Condoms when Exposed to Behavioral Interventions

Intervention	Reduction in non-use of condoms				
	High	Medium	Low	MSM	IDU
Community mobilization		-10	-2.5		
Mass media		-11.6	-17		
VCT	-44.2	-23.4	-16.1		
Condoms	-85.1	-55.1	-5.3		
Youth: in-school		-15.7			
Youth: out-of-school		-16.6			
Workplace programs		-17.1	-1.0		
Outreach	-42.5	0		-36.3	-17.9
MSM: lubricants	0	0			
IDU: needle sharing	-41.5	0			
IDU: drug substitution	0	0			

The impact on the number of sexual partners (Table 2) is determined as the number of partner in the base year multiplied by the product of the increase in coverage and the impact of each intervention.

$$n_t = n_0 \times \prod_i (\text{Coverage}_{i,t} - \text{Coverage}_{i,0}) \times \text{Number of Partners Impact}_i$$

Table 2. Reduction in Number of Partners per Year when Exposed to Behavioral Interventions

	Reduction in # of partners				
	High	Medium	Low	MSM	IDU
Community mobilization					
Mass media		-4.2			
VCT		-13.1			
Condoms		-13			
Youth: in-school		-18.3			
Youth: out-of-school		-18.3			
Workplace programs		-35.5			
Outreach	-11.2			-10.1	-1.2
MSM: lubricants					
IDU: needle sharing					
IDU: drug substitution	-46				

The impact on age at first sex, Table 3, is calculated as age at first sex in the base year multiplied by the product of the increase in coverage and the impact of each intervention.

$$AFS_t = AFS_o \times \prod_i (\text{Coverage}_{i,t} - \text{Coverage}_{i,0}) \times \text{Age at First Sex Impact}_i$$

Table 3. Increase in Age at First Sex When Exposed to Behavioral Interventions

Community mobilization	-0.3
Mass media	
VCT	
Condoms	
Youth: in-school	0.1
Youth: out-of-school	0.1
Workplace programs	
Outreach	
MSM: lubricants	
IDU: needle sharing	
IDU: drug substitution	

Similarly the impact on needle sharing, Table 4, is calculated as the proportion sharing needles in the base year multiplied by the product of the increase in coverage and the impact of each intervention.

$$NS_t = NS_o \times \prod_i (Coverage_{i,t} - Coverage_{i,0}) \times \text{Needle Sharing Impact}_i$$

Table 4. Reductions in Unsafe Injecting Behaviors When Exposed to Behavioral Interventions

	Needle Sharing
Outreach	-17.9
IDU: needle sharing	-50.7
IDU: drug substitution	-65.0

7.5.10.7 Progression of HIV-infected population

The HIV+ population is tracked by CD4 count. The model structure has seven CD4 compartments as shown below. The compartments were selected on the basis of eligibility criteria and mortality patterns.

We assume that most newly infected people start with CD4 counts above 500, although some portion, p, can start at 350-499. The transition probabilities $\lambda1$, $\lambda2$, $\lambda3$, $\lambda4$, $\lambda5$ and $\lambda6$ represent the probability of progressing from one CD4 category to the next. In each category there is some probability of death from HIV-related causes, designated as $\mu1$, $\mu2$, $\mu3$, $\mu4$, $\mu5$, $\mu6$ and $\mu7$ as well as a chance of death from non-AIDS causes, $\mu0$ (not shown in the figure). The probability of HIV-related death increases as CD4 counts decrease.

The number of people in the different CD4 count categories represents the HIV-infected population not on ART. The number of people eligible for treatment is the number in each CD4 count category that is below the recommended level for initiating ART.

Depending on the eligibility criterion and the level of first line ART coverage, a percentage of those eligible for treatment will start first line ART ($c1$, $c2$, $c3$, $c4$, $c5$, $c6$, $c7$). Those on ART are categorized by their CD4 count at the initiation of treatment. The model does not track the temporal decline of CD4 counts of those on treatment. Those on first line ART have a probability of failure depending on their CD4 count at initiation, $\alpha1$, $\alpha2$, $\alpha3$, $\alpha4$, $\alpha5$, $\alpha6$ and $\alpha7$.

The number starting ART each year is determined by the assumed coverage and the number of people in the eligible for treatment. We assume that those starting on ART will be distributed among the eligible CD4 categories such that an equal percentage of people in each eligible CD4 category initiate treatment.

Figure 3: Model of HIV-infected population, eligibility for ART and HIV-related mortality
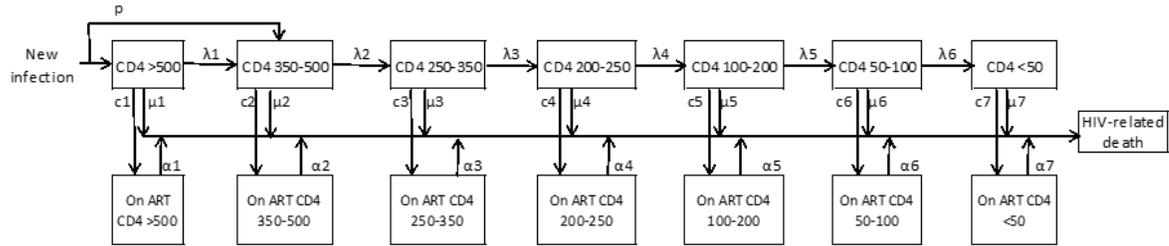
Notes:

$\lambda_1, \lambda_2, \lambda_3, \lambda_4, \lambda_5, \lambda_6$ are the annual probabilities of transitioning to the next lower CD4 group

$\mu_1, \mu_2, \mu_3, \mu_4, \mu_5, \mu_6, \mu_7$ are the annual probabilities of HIV-related mortality by CD4 group

$\alpha_1, \alpha_2, \alpha_3, \alpha_4, \alpha_5, \alpha_6, \alpha_7$ are the annual mortalities on ART by CD4 count

7.5.10.8 Allocation of new ART patients by CD4 count

The number of people on ART in each year is an input to Spectrum. It is used to determine the number of people newly starting ART in each year in order to achieve the specified number of patients. New ART patients need to be allocated across CD4 categories. Information from treatment cohorts on the distribution of new patients by CD4 count is based on a time when almost all countries defined eligibility for treatment as those with CD4 counts under 200. As most countries are now moving to the new WHO guidelines as <350, past patterns may not indicate future patterns.

We have considered two options for allocating new ART patients by CD4 count:

1. Start the same proportion on ART from each eligible CD4 category

2. Allocate new ART patients on the basis of expected AIDS mortality without ART

When comparing the two methods with data from southern Africa treatment sites it appears that the first method (allocating an equal proportion from all eligible CD4 categories) tends to under-estimate the number starting at low CD4 counts and over-estimate those starting at higher CD4 counts. Weighting the allocations by expected AIDS mortality produced the opposite results, there are too many starting at low CD4 counts and too few at higher CD4 counts. An average of the two methods produces a pattern that matches the data reasonably well. Therefore, Spectrum calculates allocations according to both methods and averages the results.

7.5.10.9 Demographic processes

People enter the model when they reach age 15. The number of people reaching age 15 in each year is provided to Goals from the demographic projection component of Spectrum. Similarly, people age out of the adult population in Goals when they reach the age of 50. Those aging out at 50 are assumed to have the same characteristics as the rest of the adult population in terms of risk group and HIV status.

In addition to aging, adults in Goals are also subject to non-AIDS mortality which is supplied to Goals by the demographic projection model in Spectrum based on age-specific non-AIDS mortality rates.

7.5.10.10 Parameter values

Values of key parameters and the sources are shown in **Table 5**.

Parameter	Value	Source
Transmission of HIV per act (female to male)	0.0011	Baggeley et al[2]., Gray et al.
Multiplier on transmission per act for		
- Male to female	1.0	
- Presence of STI	8	Galvin and Cohen[3], 2.2-11.3
		Powers et a.l[4]. 5.1-8.2
- MSM contacts	2.6	Vittinghoff et a[5]l.
Relative infectiousness by stage of infection		
- Primary infection	9 – 40	Boily et a.l[6]. 9.17 (4.47-18.81) Pinkerton[7]
- Asymptomatic	1	Reference stage
- Symptomatic	7	Boily et al[6]. 7.27 (4.45-11.88)
- On ART	0.04 – 0.08	Cohen et al.[8] Attia et al.[9]
Efficacy in reducing HIV transmission		
- Condom use	0.8	Weller and Davis[10]
- Male circumcision	0.6	Auvert et al[11], Gray et al. (2007)[12], Bailey et al.[13]
- PrEP	0.55 – 0.73	Grant et al.[14]
	0.6	Partners PrEP Study
- Microbicide		Abdool Karim et al.[15]

The time in each CD4 count category is shown in Table 7. These values have been determined by starting with values in the published literature and then fitting the model to data from the ALPHA network. Progression from infection to death is slower for young people than older people. The ALPHA network analysis[1] found a median time from infection to AIDS death of 12.8 years for those aged 15-24, 10.6 years for 25-34, 7.5 years for 35-44, and 5.6 years for 45+. They found no difference by sex once survival was adjusted for age. We have used these data to develop parameter sets for these four age groups.

A recent publication by Johansson et al. summarizes data from 6 countries on mortality by CD4 count for those not on ART. They found annual mortality of 0.8 (0.7-0.9) for those with CD4 counts <50 (from one study in Thailand), 0.355 (0.335-0.375) for those with CD4 counts between 50 and 199 from 6 studies, and 0.109 (0.093-0.125) for those with CD4 counts between 250 and 350 from six studies.

Information on the rate of CD4 cell count decline is available from a several studies, with one providing declines by CD4 category (Table 6).

Table 6. Annual declines in CD4 count among HIV-positive adults

Study	Annual Rate of Decline in CD4 Count
CASCADE, Wolbers et al.[17]	61 (46-81) Fixed effects 74 (31-145) By patient 114 (32-229) Last 2 tests
MACS, Mellors et al. JAMA, 2007[18]	64 (8-136)
CNICS, SFMHS, REACH, Rodriguez et al.[19]	50 (46-55)
Williams et al. JID, 2006[20]	85 South Africa 65 Zambia
Cape Town, Holmes et al.[21]	>500: 47 (40-54) 351-500: 31 (23-38) 201-350: 20 (14-27)

For this model the parameter values were determined by using the literature values as a starting point and fitting the model to Weibull curves of progression to mortality by age from the ALPHA network. We assumed that the rate of CD4 decline is constant across all categories and that mortality varies by CD4 category but not by age. The resulting parameter values are shown in Table 7.

Table 7. Number of years in each CD4 count category by age and sex

	Male				Female			
	15 - 24	25 - 34	35 - 44	45 -54	15 - 24	25 - 34	35 - 44	45 -54
> 500	8.02	6.95	3.96	2.47	8.02	6.95	3.96	2.47
350 - 499	3.35	2.43	1.53	0.94	3.35	2.43	1.53	0.94
250 - 349	2.23	1.62	1.02	0.63	2.23	1.62	1.02	0.63
200 - 249	1.12	0.81	0.51	0.31	1.12	0.81	0.51	0.31
100 - 199	2.23	1.62	1.02	0.63	2.23	1.62	1.02	0.63
50 - 99	1.12	0.81	0.51	0.31	1.12	0.81	0.51	0.31

Mortality while on ART has been estimated by the IeDEA (International Epidemiologic Database to Evaluate AIDS) Consortium which has analyzed data from 50,000 patients in East Africa to determine mortality of patients on ART by CD4 count at treatment initiation. In the future, mortality patterns will become available for other regions: southern Africa, West Africa, Latin America and Asia. The actual patterns used in Spectrum vary by age, sex and time on ART: 0-6 months, 7-12 months and more than 12 months as shown in Table 8.

Table 8. Annual mortality (per 100 person-years) on ART by CD4 count, age, sex and time on ART

CD4 Count by Time on ART	Males				Females			
0-6 Months	15-24	25-34	35-44	45+	15-24	25-34	35-44	45+
>500	5.84	4.42	3.91	4.40	4.22	3.19	2.82	3.18
350-500	10.53	7.97	7.05	7.93	7.61	5.76	5.09	5.73
250-349	14.33	10.85	9.59	10.79	10.35	7.83	6.93	7.80
200-249	11.13	8.43	7.45	8.38	8.04	6.09	5.38	6.06
100-199	12.78	9.68	8.55	9.63	9.23	6.99	6.18	6.95
50-99	22.74	17.21	15.22	17.13	16.42	12.43	10.99	12.37
<50	41.69	31.56	27.90	31.40	30.11	22.79	20.15	22.68
7-12 months								
>500	1.76	1.17	1.19	1.42	1.17	0.78	0.80	0.95
350-500	2.36	1.57	1.60	1.91	1.58	1.05	1.07	1.28
250-349	2.16	1.44	1.47	1.75	1.44	0.96	0.98	1.17
200-249	1.72	1.14	1.16	1.39	1.15	0.76	0.78	0.93
100-199	2.11	1.40	1.43	1.71	1.41	0.94	0.96	1.14
50-99	2.70	1.80	1.83	2.19	1.81	1.20	1.23	1.46
<50	3.43	2.28	2.33	2.78	2.29	1.52	1.56	1.86
>12 months								
>500	1.08	0.72	0.74	0.88	0.73	0.48	0.49	0.59
350-500	1.45	0.97	0.99	1.18	0.97	0.65	0.66	0.79
250-349	1.33	0.89	0.90	1.08	0.89	0.59	0.60	0.72
200-249	1.06	0.70	0.72	0.86	0.71	0.47	0.48	0.57
100-199	1.30	0.87	0.88	1.05	0.87	0.58	0.59	0.71
50-99	1.67	1.11	1.13	1.35	1.11	0.74	0.76	0.90
<50	2.12	1.41	1.44	1.71	1.42	0.94	0.96	1.15

7.5.11 References

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Journal of Acquired Immune Deficiency Syndromes. 2006; 42(4): 464-910.1097/01.qai.0000225729.79610.b7.

7.6   RNM
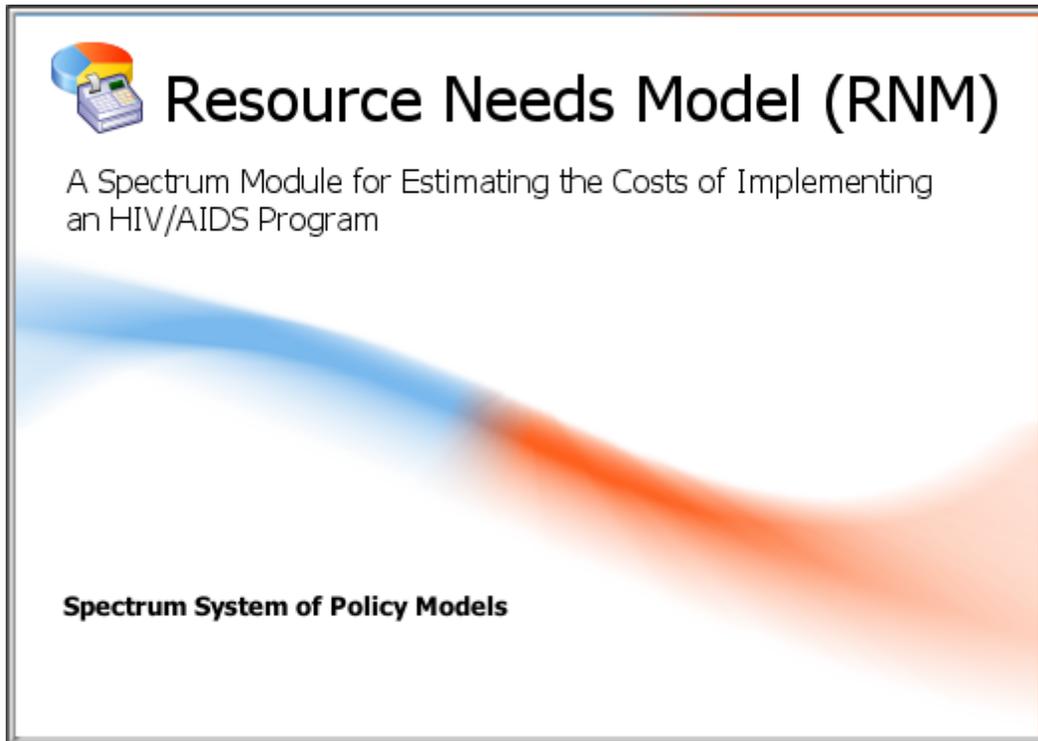
7.6.1   What is RNM?

The Resource Needs Model (RNM) is a computer program for projecting the costs of implementing an HIV/AIDS program. The RNM can assist national-level strategic planning efforts by providing a tool and methodology to examine the financial resources needed to implement a variety of prevention interventions, care and treatment programs, mitigation efforts for orphans and vulnerable children (when such programs are included as part of the HIV/AIDS strategy), and policy and program support.

The basic framework of the RNM was initially developed to estimate the costs of reaching the goals stated at the United Nations General Assembly Special Session (UNGASS) on HIV/AIDS in June 2001. Although initially the model estimated resources required for all low- and middle-income countries, over time, it evolved into a country-specific model. Various interventions were also added over the last decade, including post-exposure prophylaxis, universal precautions, safe medical injections, nutrition for those on treatment, and health systems strengthening. In addition, collaborative and comprehensive efforts resulted in the harmonization of the categories in the RNM and the National AIDS Spending Assessments conducted by UNAIDS.

The RNM projects the costs of various HIV/AIDS interventions, given assumptions about the sizes of various populations groups, unit costs of interventions, and coverage targets. These projections then can be used in graphic policy presentations intended to enhance knowledge of AIDS among policymakers and to build support for effective prevention, treatment and care, and mitigation. The projection results are usually transferred to presentation software, such as PowerPoint, for presentation to leadership audiences.

Before RNM can be used, both a demographic and an HIV/AIDS projection must be prepared. DemProj, one of the Spectrum system of policy models, is first used to make the demographic projection; see the DemProj manual for more information. The resulting age- and sex-specific population data are used in RNM as well as in making an AIM projection; see the AIM manual for more information. The *Epidemiology* section of AIM calculates the number of HIV infections, number needing treatment, and orphans. This information is used in the *Treatment* section of the RNM to calculate the costs of treatment for PMTCT, HIV/AIDS, and AIDS associated tuberculosis (TB) and opportunistic infections (OIs), and can be used in the *Mitigation* section to calculate the cost of providing services for orphans. Note that the demographic projection is modified in turn by AIM through AIDS deaths and the impact of HIV infection on fertility. Please see Figure 1 for a visual diagram of RNM.

RNM (and the entire Spectrum system of models) is designed to produce information useful for policy formulation and dialogue within a framework of computer programs that are easy to use. The focus is on generating information useful for policy and planning purposes rather than on carrying out detailed research into the underlying processes involved. For this reason, the program is designed to be used by program planners and policy analysts. RNM uses data that are readily available and requires little technical expertise beyond what can be acquired through literature review and use of this manual. RNM's focus is on generating information useful for policy and planning purposes.

Figure 1: RNM diagram
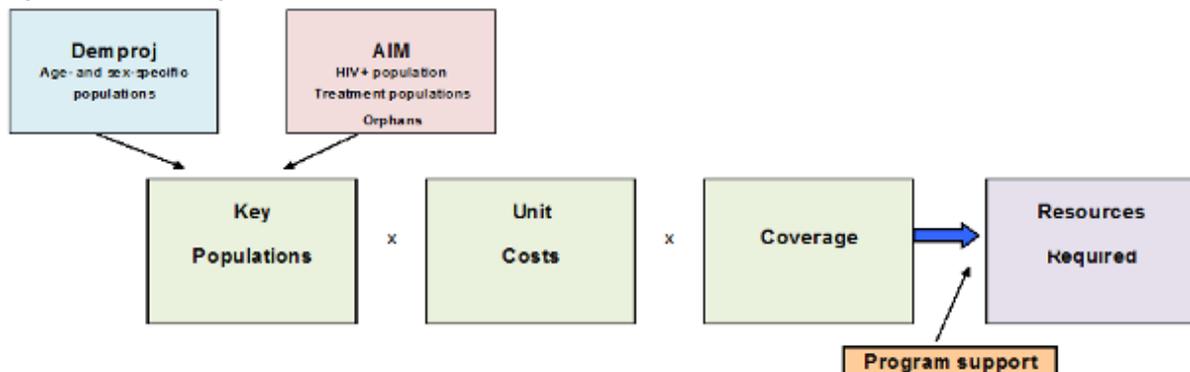
[1] Schwartlander et al. (2001) "Resource Needs for HIV/AIDS," *Science* 292:2434-2436, 29 June 2001.

7.6.2   Why make RNM projections?

A key aspect of the policy process is recognizing that a problem exists and placing that problem on the policy agenda. Projecting the financial requirements to address the HIV/AIDS epidemic can illustrate the magnitude of the epidemic. Because the Spectrum family of models is interactive, a projection can also show policymakers the impacts on other areas of development and the size of the impacts that could be expected without effective action. RNM projections can illustrate the magnitude of the costs of implementing different programs addressing the HIV/AIDS epidemic.

Note that it is often useful to prepare more than one RNM projection, and sometimes several, for two reasons. Projections are based on assumptions about the future levels of costs and other variables. Because these are uncertain assumptions, it is often wise to consider low, medium and high variants of each of these assumptions so that the range of plausible projections can be determined. In addition, when RNM projections are used for policy dialogue, it is usually important to show the results of varying

coverage target rates, the main policy variables in the module. Through changing coverage rates, the financial consequences of a varying mix of programs can be explored.

7.6.3 Steps in making an RNM projection

There are eight key steps in making most RNM projections. The amount of time spent on each step may vary, depending on the application, but most projection activities will include at least these eight steps.

1. **Prepare a demographic and HIV/AIDS epidemic projection.** RNM requires both a population projection prepared with DemProj and a projection of the HIV/AIDS epidemic prepared with AIM. For a quick start, default data are available for many countries within Spectrum; the default data are based on the estimates and projections of the United National Population Division and UNAIDS, and will be described further below.

2. **Form a national team to implement the model** The model needs to be implemented by a national team that can be trained in the use of the model. This team will generally receive some initial training in the use of the model and then extensive training as the model is set up and used. Ideally the model will be implemented by a multi-disciplinary team composed of participants with various areas of expertise (demography, epidemiology, health finance, planning) representing different aspects of society (government, civil society, private sector, donors).

3. **Collect data on socio-demographic variables, health systems, HIV prevalence and condom use, and the costs of prevention and care programs** The RNM contains default values for many of the variables used by the model. These values are derived from information obtained from published studies on the cost of prevention and care programs. This information can be used or replaced with locally available data. It also requires national data on the population size and distribution, adult HIV and sexually transmitted infections (STI) prevalence, and sexual behavior (e.g., condom use).

4. **Enter data specific to RNM** Once the data described above are collected for the relevant year, the data are entered into the RNM.

5. **Examine projections.** Once the projection is made, it is important to examine it carefully. This examination includes consideration of the various demographic and HIV/AIDS indicators produced, the age and sex distribution of the projection, and the overall financial resources required. Careful examination of these indicators can act as a check to ensure that the base data and assumptions were understood and were entered correctly into the computer program. This careful examination is also required to ensure that the consequences of the assumptions are fully understood.

6. **Make alternative projections.** Many applications require alternative HIV/AIDS projections. Once the base projection has been made, the program can be used to quickly generate alternative projections as the result of varying one or several of the projection variables.

7. **Conduct workshops on resource needs.** In most applications the model will be used in a workshop with decision-makers. The workshop will be an interactive session where participants will validate the assumptions that are important in the model, such as coverage targets and certain unit costs.

8. **Follow up on workshop outcomes** A variety of workshop outcomes are possible. Ideally the model is applied as part of the overall strategic planning process. In this case the model may continue to be used as goals are revised and funding plans are developed. The workshop may result in a new budget for the plan, or a commitment to raise additional funds to pay for essential

programs. Reports and presentations may need to be prepared in order to disseminate the results to national decision-makers, donors and program partners.

7.6.4   RNM input editors

The basic approach of the RNM is to first estimate the number of people receiving each service by multiplying the number of people needing the service by the coverage rate (the percent of those needing the service that actually receive it). The resources needed are then estimated by multiplying the number of people receiving the service by the unit cost of providing the service.

This approach can be illustrated by examining the calculations for a single prevention intervention, outreach to female sex workers (FSW). First we need to know the **population size**. Here, this is the estimated number of FSW in the country, based on either the best estimate of the current number of FSW or the percentage of adult women who are FSW. The next input is the **coverage**, or percent of FSW who are currently reached by the outreach intervention. The future coverage goal is also entered so that the model can calculate the resources needed to scale up to the coverage goal. The final input needed is the **unit cost**, the cost to provide outreach services to one FSW during one year. The unit cost can remain constant over the projection period, or can be modified.

With this information the model estimates the resources required in any year (t):

$$\text{Resources required}_t = \text{Number of FSW}_t \ \times \ \text{Coverage}_t \ \times \ \text{Unit cost}_t$$

A similar approach is followed to calculate financial resources required for each of the main interventions. In addition to these main calculations, various program-level costs are calculated either as a percentage of the total budget or as an absolute amount.

Below, you will find the descriptions for the input of each variable, in the order in which you will encounter them in the program. Default values for most of the inputs are available for many countries in the world, when that option is selected while creating the projection. Note that sometimes the population target group is a combination of results from either DemProj or AIM and assumptions made in RNM. For example, the number of primary school students is a combination of the population in a certain age group (calculated by DemProj) and the gross primary school enrollment rate entered into RNM. Only assumptions made in RNM are described here; see the DemProj or AIM manuals for detailed descriptions of their data requirements.

Also, note that other populations not currently listed in the model can be added by the user; details of this are described in the Program Tutorial chapter. When other populations are added, corresponding line items are also added in the input screens for coverage rates and unit costs.

For approximately 60 developing countries, default values are available for the RNM module based on a series of workshops held by UNAIDS in 2010[1]; these values can be used in conjunction with default values for DemProj (available for all countries) and AIM (available for most countries) to set up an initial projection. This process will be explained further in the Program Tutorial.

Demographic and HIV/AIDS Epidemic Projections

As previously noted, RNM requires that a demographic projection first be prepared using DemProj, as well as a projection of the HIV/AIDS epidemic, prepared with AIM.

There are several key factors to remember in applying these two background modules. In DemProj, default values are provided by the United Nations Population Division estimates and projections, which in turn are based on a country's most recent demographic projections. However, the HIV prevalence trend

may be different than the one used by Spectrum; in this case, adjustments need to be made either to various parameters (e.g., fertility patterns, life expectancy, model life table, migration data) or to the base population figures in DemProj. In AIM, the HIV prevalence projection is based on a number of default assumptions, all of which may be varied and have an impact on the pattern of the epidemic. Further details of all of these factors can be found in the manuals cited above.

Recall that the populations needing all of the treatment-focused interventions, including PMTCT, as well as the number of orphans, are from the AIM module.

[1] Futures Institute, "Financial Resources Required to Achieve National Goals for HIV Prevention, Treatment, Care and Support," Glastonbury, CT: June 2010.

7.6.4.1 Population sizes

7.6.4.1.1 General population

Condom provision

The following parameters are combined with population data from DemProj to calculate the number of condoms required. Many of these data can be found in a country's Demographic and Health Survey (DHS), Integrated Biological and Behavioral Surveillance Survey (IBSS), or the Behavioral Risk Surveillance System, where available.

1. Percent of population 15-49 that is sexually active.

2. Percent of males 15-49 in regular partnerships. 'Regular partnerships' refers to marriage or living together on a permanent basis.

3. Percent of males 15-49 reporting non-regular partners.

4. Number of sex acts with regular partner per year. Surveys have found that this figure varies from about 50 – 110 with a median of about 66.

5. Number of sex acts with casual non-regular partners per year. Casual partners are non-regular partners that are not sex workers.

6. Number of commercial sex acts per FSW per year.

7. Number of commercial sex acts per male sex worker (MSW) per year.

8. Percent of condoms wasted during storage and distribution. The default value is 15%.

Youth

There are two types of prevention interventions for youth: one reaching youth that are in school, and the other reaching youth that are out of school. The in-school youth programs consist of training teachers to give information about HIV/AIDS, so the costs are calculated based on how many teachers are trained, and how frequently training takes place. Out-of-school youth programs are peer education programs, where the unit cost is calculated based on the cost of reaching each out-of-school youth. The parameters below are combined with population data from DemProj to calculate the size of the different population groups. Many of these data can be found from the country's Ministry of Education, or from the World

Bank World Development Indicators (WDI) database (http://data.worldbank.org/data-catalog/world-development-indicators).

1. Primary school gross enrollment rate – males. The primary school gross enrollment rate for males is the number of male students divided by the male population of primary school age. It may be above 100% if many children younger or older than the typical age group are enrolled.

2. Primary school gross enrollment rate – females. The primary school gross enrollment rate for females is the number of female students divided by the female population of primary school age. It may be above 100% if many children younger or older than the typical age group are enrolled.

3. Primary pupil-teacher ratio. This is the average number of primary students per teacher.

4. Secondary school gross enrollment rate – males. The secondary school gross enrollment rate for males is the number of male students divided by the male population of secondary school age. It may be above 100% if many children younger or older than the typical age group are enrolled.

5. Secondary school gross enrollment rate – females. The secondary school gross enrollment rate for females is the number of female students divided by the female population of secondary school age. It may be above 100% if many children younger or older than the typical age group are enrolled.

6. Secondary pupil-teacher ratio. This is the average number of secondary students per teacher.

7. Frequency of teacher re-training (years). The number of years after which teachers are re-trained in HIV/AIDS education.

Workplace programs

Workplace programs are prevention interventions provided to employees in the work place. We assume that these interventions are targeted to employees in the formal sector, and can consist of both peer education and STI treatment. These data can usually be found in a country's national statistics, or from the International Labour Organization.

1. Formal sector employees eligible for workplace programs. The number of formal sector employees, or the percentage of the population aged 15-49, who are employed by organizations who would offer workplace programs. Note that this target population may include all sectors, including agriculture.

Violence against women

The intervention here consists of providing someone who may have been newly exposed to HIV via rape a post-exposure prophylaxis (PEP) kit (antiretroviral treatment), usually for one month. The United Nations publishes statistics on reported rapes in their annual Survey on Crime Trends.

1. Rapes per 1000 population. The reported number of rapes is usually used, as those are the people who would receive PEP kits.

7.6.4.1.2 Most-at-risk populations

There are several methods that have been used for estimating the size of populations at higher risk, such as sex workers, men who have sex with men (MSM), and injecting drug users (IDU). These include census and enumeration, capture-recapture, multiplier methods, nomination methods, and population surveys. A good source of information on how to estimate population sizes is available from UNAIDS[1]. In addition, various publications cited below for the relevant population group provide estimates of some of the key populations. Note that input can be provided in either numbers or percentages. Each of the key populations below is assumed to grow at the same rate as the population of both sexes aged 15-49 in DemProj. If the Goals module is active, the growth rate is provided by Goals.

1. Female sex workers. The percentage is relative to females aged 15-49. One possible data source is: "Female sex workers: estimates of the number of female sex workers in different regions of the world." J Vandepitte, R Lyerla, G Dallabetta, F Crabbe, M Alary, A Buve. *Sexually Transmitted Infections.*   2006; 82; 18-25.

2. Male sex workers. The percentage is relative to males aged 15-49.

3. Men who have sex with men. The percentage is relative to males aged 15-49. One possible data source is: "Estimating the number of men who have sex with men in low and middle income countries." C Caceres, K Konda, M Pecheny, A Chatterjee, R Lyerla. *Sexually Transmitted Infections.*   2006; 82; 3-9.

4. Injecting drug users. The percentage is relative to those aged 15-49. Two possible data sources are: "Estimates of injecting drug users at the national and local level in developing and transitional countries, and gender and age distribution." C Aceijas, SR Friedman, HLF Cooper, L Wiessing, GV Stimson, M Hickman, and on behalf of the Reference Group on HIV/AIDS Prevention and Care among IDU in Developing and Transitional Countries. *Sexually Transmitted Infections.* 2006; 82; 10-17; "Global epidemiology of injecting drug use and HIV among people who inject drugs: a systematic review." BM Mathers, L Degenhardt, B Phillips, L Wiessing, M Hickman, SA Strathdee, A Wodak, S Panda, M Tyndall, A Toufik, RP Mattick, 207 Reference Group to the UN on HIV and Injecting Drug Use. *Lancet*   . 2008 Nov 15; 372(9651): 1733-45.

5. Percent IDU opioid dependent. The same two data sources as for number of IDU immediately above may contain data for this input as well.

6. Injections per year. The number of times the average IDU injects per year.

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[1] "Estimating the Size of Populations at Risk for HIV: Issues and Methods." UNAIDS/FHI. Available at www.UNAIDS.org.

7.6.4.1.3 Medical services

STI management

This intervention calculates the cost of treating STIs in a clinical setting, that is, excluding infections treated in the workplace or through other interventions such as sex worker outreach. The initial number increases by the population growth rate for those aged 15-49 for the overall projection. If the Goals module is active, this growth rate is provided by Goals.

1. Number of new cases of treatable STIs – male. The annual number of new cases of sexually transmitted infections in males. The percent is relative to males aged 15-49.

2. Number of new cases of treatable STIs – female. The annual number of new cases of sexually transmitted infections in females. The percent is relative to females aged 15-49.

3. STIs that are symptomatic: Males. Either the number or the percent of treatable STIs in males that are symptomatic and, therefore, likely to be identified for treatment.

4. STIs that are symptomatic: Females. Either the number or the percent of treatable STIs in females that are symptomatic and, therefore, likely to be identified for treatment.

Blood safety

Blood safety consists of screening donated blood for HIV. The only input required to estimate the need for safe blood is the number of units of blood required per 1000 people. This figure should be available from the national blood transfusion service; one other possible data source is the World Health Organization's Global database on blood safety, available at: http://www.who.int/bloodsafety/global_database/en/ .

1. Blood units required per 1,000 people. This should be for the total population, including children.

Post-exposure prophylaxis

Post-exposure prophylaxis (PEP) refers to antiretroviral treatment provided, usually for one month, to a person who may have been newly exposed to HIV. This is typically provided for health care personnel who may have come in contact with infected blood through a needle stick or other accident.

1. The estimate of need is based on the estimated number of PEP kits per million population, which in turn should vary by HIV prevalence rate. PEP kits required per million population. This should be for the total population, including children.

Safe medical injection

HIV can be spread through medical injections with contaminated needles and syringes. Interventions to prevent contaminated injections promote the use of needles and syringes that can only be used once (auto-destruct needles) and the reduction of unnecessary injections. The number of unsafe injections is estimated from three inputs.

1. Average number of immunizations per child 0-23 months. This should be the actual number of injections per child between the ages of birth and 23 months, not the recommended number. The DHS usually contains data on this input.

2. Adult injections per person per year. This is the number of adult injections per person per year, including both women and men. See below for possible data.

3. Injections that are unsafe. This is either the number or percent of injections that are unsafe. See below for possible data.

WHO has estimated the number of adult injections per person per year and the percent of injections that are unsafe by region, as shown in the table below.

Region	Injections per person per year	Percent of injections that are potentially unsafe
Afr D : Algeria, Angola, Benin, Burkina Faso, Cameroon, Cape Verde, Chad, Comoros, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Equatorial Guinea, Liberia, Madagascar, Mali, Mauritania, Mauritius, Niger, Nigeria, Sao Tomé-et-Principe, Senegal, Seychelles, Sierra Leone, Togo.	2.2	19 %
Afr E : Botswana, Burundi, Central African Republic, Congo, Côte d'Ivoire, Democratic Republic of the Congo, Eritrea, Ethiopia, Kenya, Lesotho, Malawi, Mozambique, Namibia, Rwanda, South Africa, Swaziland, Uganda, United Republic of Tanzania, Zambia, Zimbabwe.	2.0	17 %
Amr B : Antigua and Barbuda, Argentina, Bahamas, Barbados, Belize, Brasil, Chile, Colombia, Costa Rica, Dominica, Dominican Republic, El Salvador, Grenada, Guyana, Honduras, Jamaica, Mexico, Panama, Paraguay, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and Grenadines, Suriname, Trinidad and Tobago, Uruguay, Venezuela.	1.7	1 %
Amr D : Bolivia, Écuador, Guatemala, Haiti, Nicaragua, Peru.	1.9	11 %
Emr D : Afghanistan, Djibouti, Égypt, Iraq, Morocco, Pakistan, Somalia, Sudan, Yemen.	4.3	70 %
Eur B : Albania, Armenia, Azerbaijan, Bosnia-Herzegovina, Bulgaria, Georgia, Kyrgyzstan, Uzbekistan, Poland, Romania, Slovakia, Tajikistan, The Former Yugoslav Republic of Macedonia, Turkey, Turkmenistan, Yugoslavia.	2.5	1 %
Eur C : Belarus, Estonia, Hungary, Kazakhstan, Latvia, Lithuania, Republic of Moldova, Russian Federation, Ukraine.	3.5	11 %
Sear B : Indonesia, Sri Lanka, Thailand.	2.1	30 %
Sear D : Bangladesh, Bhutan, Democratic People's Republic of Korea, India, Maldives, Myanmar, Nepal.	4.0	75 %
Wpr B : Cambodia, China, Cook Islands, Fiji, Kiribati, Lao People's Democratic Republic, Malaysia, Marshall Islands, Micronesia (Federated States of), Mongolia, Nauru, Niue, Palau, Papua New Guinea, Philippines, Republic of Korea, Samoa, Tonga, Tuvalu, Vanuatu, Viet Nam	2.3	30 %
World	3.4	40 %
Source : AM Hauri, GL Armstrong, YJF Hutin. "The global burden of disease attributable to contaminated injections given in health care settings," International Journal of STDs & AIDS, 2004; 15: 7-16.		

Universal precautions

"Universal precautions" refers to the use of gloves, masks and gowns by health care personnel to avoid infection through contaminated blood. The need for universal precautions is estimated from the number of hospital beds, as that is how unit costs are usually calculated. These data should be available from the Ministry of Health.

1. Hospital beds per 1000 population. This should be for the total population, including children.

7.6.4.1.4 Male circumcision

This intervention calculates the cost of circumcising both infant and adult males, and includes both medical and traditional male circumcision. In general, the male circumcision rate reported by surveys such as the DHS report both types of circumcision aggregated, so it is impossible to parse out which were medical and which were traditional. Note that the target population for early infant male circumcisions is all male births.

1. Adult males currently circumcised. The number or percent of adult males currently circumcised, either medical or traditional. The percent is relative to adult males aged 15-49.

7.6.4.2   Coverage

Information on base year coverage should be available from national service statistics, as well as other national-level surveys. Another source that is web-based is the series of country progress reports posted on the UNAIDS web site (see http://www.unaids.org/en/dataanalysis/knowyourresponse/countryprogressreports/2012countries/); these most likely contain the most recent data on coverage of certain key interventions. Note that the information on coverage may be available as the number of people receiving the service, such as the number of VCT clients, rather than as a percentage. In this case, you would adjust the estimated coverage until you get the correct number of people served.

The future coverage targets can be whatever the program wishes to achieve. Generally these are set in terms of comprehensive coverage that provides equitable access to prevention services and has a significant impact on the epidemic. For some interventions the obvious target coverage may be 100%, such as safe blood or school-based AIDS education. For others it may be unrealistic to expect to reach 100% of the population in need and a target of 80% may be more feasible. For example, the UNGASS target for PMTCT is to reach 80% of women accessing antenatal care. For others the target should be set to have an impact on transmission. Studies have shown that in order to have a significant impact on transmission interventions for sex workers, men who have sex with men, injecting drug users and other populations at higher risk need to reach coverage levels of between 60-80%.

Note that, if desired, the "expand" option can be selected at the bottom of the input screen; if selected, columns are expanded and coverage rates can be entered for all of the years between the base year and target year. Note also that coverage may be set to zero if any of the interventions are not part of the HIV/AIDS program.

7.6.4.2.1 General population

Community mobilization

Community mobilization programs may include a wide variety of activities such as: paid or volunteer community mobilizers who may go door-to-door or organize special community events, church-based programs that include AIDS messages in sermons, church events and youth programs, and efforts to build support for HIV prevention among chiefs, elders and other community leaders. The target population is the adults in the population.

1. Reached by intervention per year. The percent of the adult population (aged 15-49) that is reached by community mobilization efforts each year.

Mass media

Mass media programs generally include print and radio channels and may also include television, hot lines, theater and special events. The population in need of mass media is assumed to be the entire adult population.

1. Reached by campaigns per year. The percent of the adult population (aged 15-49) that is reached by mass media campaigns each year.

Voluntary counseling and testing

Voluntary counseling and testing (VCT) refers to the provision of counseling (both pre-test and post-test counseling)as well as the actual HIV test. The services can be provided in a variety of settings, including VCT centers, medical clinics, mobile vans, or at home.

1. Adult population receiving VCT each year. The percent of the adult population (aged 15-49) that receives VCT each year.

Condom provision

This coverage rate refers to the condoms provided to the general population, excluding those condoms provided by outreach programs to key populations (FSW, MSW, MSM, IDU) and other interventions. The coverage rate refers specifically to the percent of sex acts where a condom is needed, defined by the various parameters provided in the "Condom provision" entries in the General Population tab (see above for descriptions).

1. Condom coverage. The percent of the sex acts of the adult population using condoms each year.

Youth

Three different coverage rates are required to estimate resources required for interventions reaching youth in primary and secondary school, as well as youth not attending school.

1. Primary students with teachers trained in AIDS. The percent of primary school students who have teachers trained in HIV/AIDS education.

2. Secondary students with teachers trained in AIDS. The percent of secondary school students who have teachers trained in HIV/AIDS education.

3. Out-of-school youth reached. The percent of youth not attending school reached by an HIV/AIDS intervention.

Workplace programs

This intervention may consist of two parts: peer education and STI treatment, thus requiring two separate coverage rates.

1. Workforce receiving peer education. The percent of the formal sector labor force receiving peer education in the workplace each year.

2. Workforce receiving STI treatment. The percent of the formal sector labor force receiving STI treatment the workplace each year.

7.6.4.2.2 Most-at-risk populations

Female sex workers

Outreach for female sex workers may include peer education, general IEC, condom distribution, and/or STI treatment.

1. Sex workers reached by intervention per year. The percent of female sex workers that is reached by outreach interventions each year.

Male sex workers

Similarly, outreach for male sex workers may include peer education, general IEC, condom and lubricant distribution, and/or STI treatment.

1. Sex workers reached by intervention per year. The percent of male sex workers that is reached by outreach interventions each year.

Men who have sex with men

Outreach programs for MSM may include peer education, general IEC, and the distribution of condoms and/or lubricants. There are two separate coverage rates for this category.

1. MSM reached by intervention per year. The percent of MSM that is reached by outreach interventions each year, excluding those interventions distributing lubricants.

2. MSM receiving lubricants. The percent of MSM receiving lubricants each year.

Injecting drug users

There are a number of different interventions for injecting drug users (IDU), including risk reduction information, education and counseling through peer outreach or the community; access to sterile injection equipment through needle and syringe exchange, distribution or vending, and/ or decontamination programs; and drug substitution programs. Each intervention requires a base and target coverage.

1. IDUs receiving harm reduction intervention. The percent of IDUs receiving harm reduction interventions each year.

2. IDUs receiving counseling and testing. The percent of IDUs receiving counseling and testing each year.

3. IDUs receiving community outreach or peer education. The percent of IDUs receiving community outreach or peer education each year.

4. IDUs receiving needle and syringe exchange. The percent of IDUs participating in needle and syringe exchange programs each year.

5. IDUs receiving drug substitution. The percent of IDUs participating in drug substitution programs each year.

7.6.4.2.3 Medical services

STI management

As noted above, this intervention takes place in medical facilities, and excludes STI treatment provided through any other intervention such as sex worker outreach. The target population is a combination of newly incident STI cases and the percent that are symptomatic, provided in the Population inputs above.

1. Males with STI receiving treatment. The percent of males with new and symptomatic STIs that receive treatment each year.

2. Females with STI receiving treatment. The percent of females with new and symptomatic STIs that receive treatment each year.

Blood safety

The intervention is the testing of donated units of blood for HIV.

1. Units of blood for transfusions tested. The percent of blood units tested for HIV each year.

Post-exposure prophylaxis

The need for PEP kits is the sum of the PEP kits needed for post-rape cases and the PEP kits required for medical personnel experiencing needle sticks and other medical accidents.

1. Need that is met. The percent of PEP kits needed that are supplied each year.

Safe medical injection

Interventions for safe medical injections consist of both using auto-destruct (AD) syringes and reducing unnecessary injections. The need for PEP kits is the sum of the PEP kits needed for post-rape cases and the PEP kits required for medical personnel experiencing needle sticks and other medical accidents.

1. Unsafe injections replaced with AD syringes. The percent of unsafe injections that are replaced with AD syringes each year.

2. Reduction in number of other injections. The percent reduction in the number of injections that are *not* replaced with AD syringes.

Universal precautions

Since the cost for universal precautions is usually cited per hospital bed, the target population is number of hospital beds (see above), and the coverage rate also refers to hospital beds.

1. Hospital beds covered. The percent of hospital beds that is supplied with universal precautions each year.

7.6.4.2.4 Male circumcision

The base coverage rate is the sum of both traditional and medical male circumcision. The early infant coverage target rate refers to male births, while the adult coverage rate refers to adult males aged 15-49. Note that, if the population is increasing, maintaining the same coverage rate results in some new male circumcisions occurring.

1. Percent of adult males circumcised. The percent of adult males that are currently circumcised in a particular year.

2. Percent of infant males circumcised. The percent of infant males that are circumcised in a particular year.

7.6.4.2.5 Treatment

The inputs for the Treatment tab in the Coverage section of the RNM module are identical to inputs in the AIM module. In addition, the two sets of numbers are connected, such that changing one number in one module also changes the same number in the other module.
Note that coverage rates for adult treatment only are entered in the RNM module; coverage rates and programmatic choices for PMTCT and child ART are entered in the AIM module.

Eligibility for treatment

Eligibility for antiretroviral treatment is based on a person's CD4 count, and can vary over time. Prior to 2010, the World Health Organization recommended that antiretroviral treatment (ART) begin when someone's CD4 count went below 200; beginning in 2010, that recommendation changed to 350. These recommendations are reflected in the default values for treatment eligibility, which changed in 2010 from 200 to 350.

1. CD4 count threshold for eligibility. The CD4 count below which ART is recommended.

Antiretroviral therapy

The males and females who are receiving ART can be entered either as a number *or* as a percent (the program will not allow you to enter both). Note that the statistic should be from December 31 for the relevant year.

1. Number of adults receiving ART, males and females. The number of adults receiving ART on December 31 should be entered for each year, separately for males and females.

2. Percent of adults receiving ART, males and females. The percent of adults receiving ART on December 31 should be entered for each year, separately for males and females. The percent is relative to adults aged 15-49.

3. Migration from first line to second line. The percent of people who migrate from first line ART to second line ART after failing first line therapy.

7.6.4.3 Unit costs

Unit cost estimates should be program costs, that is, the expenditure required by the program to implement the intervention. This is different from the economic costs which would include more costs, such as the value of donated commodities and volunteer labor. Information on unit costs may be available from the organizations implementing the interventions. A manual and model for estimating unit costs is available from UNAIDS. In addition, a number of countries have provided unit cost estimates at a series of resource needs workshops organized by UNAIDS. Where these are available they are provided as country-specific default values in the RNM module. One additional resource is the Unit Cost Repository developed and maintained by Avenir Health, which contains detailed information on unit cost data for HIV prevention and treatment interventions published in the literature, available at: http://policytools.avenirhealth.org/UC/ .

Note that some of the wide variation in the unit costs is due to different elements being offered by different countries for various interventions. For example, some countries may include treatment of STIs in their intervention targeting sex workers, which results in a higher unit cost.

Data for individual years in the projection, rather than just the base year, can be entered by clicking on the "Expand" button at the bottom of the input screen.

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[1] Costing Guidelines for HIV Prevention Strategies, UNAIDS, Geneva: 2000. Available at: http://www.tsfsouthernafrica.com/guides/strat_op_plan/folder2/2.12%20Costing%20guidelines%20for%20HIV%20prevention%20strategies.pdf .

7.6.4.3.1 General population

Community mobilization

The cost for community mobilization programs should represent the activities that are included in the intervention, which may vary from paid or volunteer community mobilizers, to church-based programs and efforts to build support among community leaders.

1. Cost per person reached. The annual cost per adult reached by a community mobilization program.

Mass media

Mass media costs include the costs associated with all mass media campaigns directed toward the adult population regarding HIV/AIDS.

1. Cost per person reached. The annual cost per adult reached by mass media.

Voluntary counseling and testing

The cost for VCT should reflect the service delivery mode of the intervention (e.g., VCT center, mobile van, home testing). If more than one service delivery mode is being utilized, a weighted average for the unit cost should be used, weighted by the relative number of people reached by each mode of delivery.

1. Cost per VCT client. The annual cost per adult receiving VCT.

Condom provision

The cost of a distributed condom should reflect the cost to the government. Sometimes this cost will be the commodity cost alone, while other times the cost will include the distribution costs associated with it, including operational and management costs. These unit costs include costs such as cost of the condom, operations, management, technical assistance and other indirect costs.

1. Cost per male condom distributed by the public sector.

Youth

The cost for teacher training is for one training; recall that the frequency of the training is specified in the Population section of the RNM module.

1. Cost per teacher trained in primary school education. This is the cost to train a primary school teacher in HIV/AIDS education.

2. Cost per teacher trained in secondary school education. This is the cost to train a secondary school teacher in HIV/AIDS education.

3. Cost of peer education for out of school youth.

Workplace programs

There are two components of workplace programs for which unit costs need to be supplied. If one of the components is not offered, simply leave the unit cost equal to zero.

1. Cost per person in employment reached (peer education). The annual cost per employee reached by peer education.

2. Cost per STI treated in the workplace.

7.6.4.3.2 Most-at-risk populations

Female sex workers

The cost for a female sex worker outreach program should include all elements of the program, including peer education, condom distribution, and STI treatment, if provided.

1. Cost per sex worker targeted. The annual cost per female sex worker targeted by the outreach program.

Male sex workers

The cost for a male sex worker outreach program should include all elements of the program, including peer education, condom distribution, lubricants, and STI treatment, if provided.

1. Cost per sex worker targeted. The annual cost per male sex worker targeted by the outreach program.

Men who have sex with men

An MSM intervention consists of one or more elements, including IEC materials, peer education, condom and lubricant distribution, and STI treatment. The cost for an MSM intervention should include all these elements; note that the cost of lubricants is provided separately.

1. Cost per MSM targeted. The annual cost per MSM targeted by the outreach program, excluding the cost of lubricants.

2. Cost of MSM lubricants per person. The annual cost of lubricants per person distributed by the program.

Injecting drug users

The costs for IDU interventions are entered separately, instead of being bundled together as is the case with sex worker and MSM interventions. There are five unit costs for IDU interventions; all are annual costs, except for the cost per needle distributed and destroyed.

1. Cost of harm reduction programs per person contacted

2. Cost of counseling and testing per IDU targeted

3. Cost of community outreach and peer education per IDU targeted

4. Cost per needle distributed and destroyed

5. Cost of drug substitution per IDU targeted

7.6.4.3.3 Medical services

STI management

The unit cost for STI management at medical facilities should include all components required to treat one STI case, including testing, treatment, and cost of the visit.

1. Cost per STI treated in clinics. The cost of treating one STI case in a medical facility.

Blood safety

The only unit cost required is the cost of screening blood for HIV. This is the cost of screening for HIV only, not the cost of blood collection, transfusion services or screening for other diseases.

1. Cost of screening a unit of blood for HIV.

Post-exposure prophylaxis

1. Cost per PEP kit. The cost of one PEP kit used to treat exposure to HIV via rape or needle sticks.

Safe medical injection

The only unit cost input is the additional cost per auto-destruct syringe provided, that is, the difference between the cost of AD syringes and re-usable syringes.

1. Additional cost for AD syringes. This is the additional cost per syringe.

Universal precautions

1. Annual cost per hospital bed. The annual cost per hospital bed of supplying universal precautions.

7.6.4.3.4 Male circumcision

There are two unit costs for male circumcision, one for adult MCs and another for early infant MCs. If both traditional and medical male circumcision is implemented, a weighted average should be used for the unit cost. The unit costs should include all elements of the program, including personnel time, commodities costs, facility overhead costs, as well as demand creation activities and counseling and testing, where provided.

1. Cost per adult circumcision. The (weighted) unit cost per adult male circumcision.

2. Cost per early infant circumcision. The unit cost per early infant male circumcision.

7.6.4.3.5 PMTCT

Comprehensive PMTCT programs for pregnant women include pre-test counseling, HIV testing, post-test counseling, antiretroviral treatment, and counseling on infant feeding options. The 2010 WHO guidelines[1] recommend a number of different antiretroviral therapy options, including Option A, Option B, and Option B+. Antiretroviral therapy may be a single drug regimen, a triple drug prophylactic regimen, or a highly active triple drug regimen (AZT + 3TC + NRTI/NNRTI or PI). In addition, programs may provide infant formula for a period of six months or longer.

Recall that the target population for PMTCT is calculated in the AIM module. In addition, the coverage rates for the different programmatic choices for PMTCT, that is, the choice(s) of ART regimens, are also made in the AIM module. In the RNM module, unit costs are input and combined with target population and coverage rates in order to calculate both PMTCT costs and a benefit-cost ratio.

Note that, if more than one regimen is provided by the PMTCT program for either triple treatment or triple prophylaxis, a weighted average of the different costs should be used.

Counseling (per mother)

1. Pre-test. The cost per mother of pre-test HIV counseling. Costs will vary depending on whether this is done individually or in groups, using opt-in or opt-out methods.

2. Post-test for HIV+. The cost per HIV+ mother of post-test counseling. It is assumed that those mothers testing negative do not require post-test counseling.

3. Post-natal (including breastfeeding). The cost per HIV+ mother of post-natal counseling, including counseling about breastfeeding options.

HIV testing (per test)

1. Mother. The cost per mother of her HIV test.

2. PCR for infant after birth. The cost of a PCR test for HIV for the infant immediately after birth.

3. Infant after cessation of breastfeeding. The cost of an HIV test for the infant after breastfeeding ceases.

ARVs (cost per person per day)

1. Nevirapine, 200 mg for mother. The cost of 200 mg of nevirapine for an HIV+ mother.

2. Nevirapine, for infant. The cost of a daily dose of nevirapine for an infant.

3. AZT. The cost of a daily dose of AZT (Azidodeoxythymidine, also known as zidovudine, or ZDV).

4. 3TC. The cost of a daily dose of 3TC (Epivir, also known as lamivudine).

5. Triple treatment. The cost of triple ART, when ART is started either before or during pregnancy. If more than one ARV regimen is implemented, use a weighted average for costs.

6. Triple prophylaxis. The cost of triple prophylaxis, when ART is part of a prophylactic program (e.g., Option B). If more than one ARV regimen is implemented, use a weighted average for costs.

Service delivery (per mother)

1. Service delivery (per mother). The service delivery unit cost associated with treating the HIV+ mother with ARVs.

Formula (per child)

1. Formula (per child). The cost per child of providing formula for a certain length of time, usually between six months and one year.

[1] WHO, "Antiretroviral drugs for treating pregnant women and preventing HIV infection in infants," available at: http://www.who.int/hiv/pub/mtct/PMTCTfactsheet/en/index.html .

7.6.4.3.6 Treatment

Similar to the calculations for PMTCT, both target population (adults and children) and coverage rates used to calculate treatment costs are taken from the AIM module, while the different components of treatment unit costs are input in the RNM module. Recall that, although adult treatment coverage rates can be specified in the RNM module, the inputs are connected to the same inputs in the AIM module, so that a change in a value in one module results in the same change in the other module. Child treatment coverage rates and programmatic choices are entered in the AIM module only.

The costs of treatment are calculated only in the RNM module. Treatment costs are split into two main parts: drugs and laboratory costs, and service delivery costs. Treatment can be provided using different combinations of service delivery modes. For example, in-patient care might be necessary to treat opportunistic infections, particularly severe ones, but ART might be delivered primarily through clinics or hospital out-patient departments.

One reason for this approach is to utilize the database associated with the WHO *CHO* osing nterventions that are ost- ffective research (WHO-CHOICE). This database provides unit cost information for both in-patient and out-patient visits for the 191 member states. The cost of one hospital bed-day is the "hotel" cost, that is, including personnel, capital and food costs, but excluding drugs and laboratory tests. The cost of one out-patient visit also includes all cost components except drugs and laboratory tests. Thus these costs can be combined with the number of in-patient days and out-patient visits per patient to calculate total service delivery costs (see Table 1). These costs are then added to drug and laboratory costs to calculate total treatment costs.

Table : Number of in-patient days, out-patient visits, and lab costs for ART and OIs

Country	ARV 1st Line			OI			Source
	#OPV	#IPD	Lab cost (USD)	#OPV	#IPD	Drug/lab cost (USD)	
Cote d'Ivoire			$51.98			$131.16	Goldie SJ, Y Yazdanpanah, E Losina, et al., "Cost-Effectiveness of HIV Treatment in Resource-Poor Settings - The Case of Côte d'Ivoire." NEJM 355;11(1141-1153).
Ethiopia	9		$207.44				Kombe G, D Galaty, R Gadhia, C Decker. The Human and Financial Resource Requirements for Scaling Up HIV/AID Services in Ethiopia. PHRPlus, Feb 2005.
Mexico	10	12.17	$366.00	6.2	9.7	$48.67	Bautista SA, T Dmytraczenko, G Kombe, SM Bertozzi. "Costing of HIV/AIDS Treatment in Mexico." PHRPlus report, June 2003.
Nigeria	12		$204.00				PHRPlus. Nigeria: Rapid Assessment of HIV/AIDS Care in the Public and Private Sectors. August 2004.
Rwanda				29.28	68.64	$39.86	Vinard P, B Nzigiye, S Rugabirwa. Etude sur le cout de la prise en charge des PVVIH. Prejet Int/107 - Initiative ESTHER en collaboration avec la CNLS. Dec 04-Mar 05.
South Africa	5.62	0.45	$37.00	3.0	4.5		Cleary SM, D McIntyre, AM Boulle. "The Cost-effectiveness of Antiretroviral Treatment in Khayelitsha, South Africa - A Primary Data Analysis." Cost Eff Resource Alloc 2006, 4:20, available at http://www.resource-allocation.com/content/4/1/20.
South Africa	8.17	1.56		5.48	9.56		Badri M, G Maartens, S Mandalia, LG Bekker, JR Penrod, et al. Cost-Effectiveness of Highly Active Antiretroviral Therapy in South Africa. PLoS Med 3(1): e4 doi:10.1371/journal.pmed.0030004. 2006.
Thailand	12		$459.20		19.2		Katajima T, Y Kobayashi, W Chaipah, H Sato, W Chadbunchachai, R Thuennadee. "Costs of Medical Services for Patients with HIV/AIDS in Khon Kaen, Thailand." AIDS 2003 Nov 7;17(16):2375-81.
Uganda	12		$74.00	2.77		$53.63	Chandler R, C Decker, B Nziyige. "Estimating the Cost of Providing Home-based Care for HIV/AIDS in Rwanda." PHRPlus paper June 2004.
Zambia	4		$177.88			$42.25	Kombe G, O Smith. "The Costs of Anti-Retroviral Treatment in Zambia." PHRPlus October 2003. Huddart J, R Furth, JV Lyons. "The Zambia Workforce Study: Preparing for Scale-up." April 2004; available at http://www.qaproject.org.
Median	9.5	1.56	$190.94	5.475	9.7	$48.67	

Note that, if more than one regimen is provided by the ART program, a weighted average of the different regimen costs should be used. Also note that the number of years for input data are automatically expanded for treatment costs; possible manipulations of the input data (e.g., copying or interpolating between years) will be discussed in the Program Tutorial section.

Drug cost data sources include the Ministry of Health's procurement strategy, the Global Fund web site (http://www.theglobalfund.org), and the Clinton Health Access Initiative web site (http://www.clintonhealthaccess.org).

Adults (costs per patient per year)

1. First-line ART drugs. The cost per adult per year of first-line ART drugs. If more than one regimen is offered, a weighted average should be entered.

2. Second-line ART drugs. The cost per adult per year of second-line ART drugs. If more than one regimen is offered, a weighted average should be entered.

3. Additional ART drug costs for TB patients (male). The additional cost resulting from substituting efavirenz for nevirapine for males with active TB (per WHO guidelines).

4. Additional ART drug costs for TB patients (female). The additional cost resulting from substituting efavirenz for nevirapine for females with active TB (per WHO guidelines).

5. Lab costs for ART treatment. Annual laboratory test costs for adults receiving ART, including initial testing and tests associated with both first-line and second-line therapy. A weighted average of costs should be used where there is a mix of new, first-line, and second-line patients.

6. Drug and lab costs for opportunistic infections. Annual drug and laboratory test costs for adults with opportunistic infections who are not on ART.

7. Cotrimoxazole prophylaxis. The annual cost of providing adults with cotrimoxazole, a prophylaxis against opportunistic infections. This is provided only to HIV+ adults who are not receiving ART.

8. TB prophylaxis. The annual cost of providing adults with prophylaxis for tuberculosis. This is provided only to HIV+ adults who are not receiving ART.

9. Nutrition supplements in first six months. The cost of providing six months of nutritional supplements to adults newly starting ART.

Children (costs per patient per year)

1. ARV drugs. The cost per child per year of ARV drugs. If more than one regimen is offered, a weighted average should be entered.

2. Lab costs for ART treatment. Annual laboratory test costs for children receiving ART. A weighted average of costs should be used where there is a mix of test regimens.

Service delivery costs

1. Cost per in-patient day. The cost for one in-patient day of care. One possible source for this is the WHO-CHOICE database (referenced above).

2. Cost per out-patient visit. The cost for one out-patient visit. One possible source for this is the WHO-CHOICE database (referenced above).

Service delivery requirements (per patient per year)

1. ART: in-patient days. The number of days per patient per year spent in hospital while on ART. One possible data source for this is the Methodological Annex III (referenced above).

2. ART: out-patient visits. The number of out-patient visits per patient per year while on ART. One possible data source for this is the Methodological Annex III (referenced above).

3. OI treatment: in-patient days. The number of days per patient per year spent in hospital while *not* on ART. One possible data source for this is the UNAIDS Methodological Annex III (referenced above).

4. OI treatment: out-patient visits. The number of out-patient visits per patient per year while *not* on ART. One possible data source for this is the UNAIDS Methodological Annex III (referenced above).

[1] WHO-CHOICE database, available at: http://www.who.int/choice/costs/en/.

[2] For a discussion of some relevant data regarding number of in-patient days and out-patient visits, see L Bollinger and J Stover, "Methodological Annex III: Methodology for Care and Treatment Interventions," UNAIDS 2007, available at: http://data.unaids.org/pub/Report/2007/20070925_annex_iii_treatment_care_methodology_en.pdf.

7.6.4.4 Program support

Program support includes the policy, management and administration, research, and monitoring and evaluation activities necessary to support the implementation of a national program. These costs are not directly related to the number of people receiving care, as they refer to costs that operate across a number of different service delivery points, such as training, and monitoring and evaluation.

Resources for these functions are estimated either as a percent of total direct program resources, or as an absolute amount. An often used rule-of-thumb is that five percent of program funding should be allocated to monitoring and evaluation. Similar percentages may be appropriate for the other functions.

Note that the number of years for data input can be increased by clicking the "Expand" button at the bottom of the input screen.

Enabling environment

This refers to funding related to improving the enabling environment, including both the social and legal environments, for example passing, monitoring and enforcing legislation related to discrimination based on HIV status, gender or risk behavior.

Program management

Program management costs refer to the operation of the national HIV/AIDS coordinating body, usually a National AIDS Control Council. This item includes all the costs of running the Council (personnel salaries,

supplies, communications, transport, rent, meetings) but not pass through funds that go directly to other organizations for the implementation of programs.

Research

Research costs include support for programs that collect primary data (such as national surveys, cohort studies, operations research, clinical trials), as well as data analysis, report writing and dissemination.

Monitoring and evaluation

Costs for M&E include the salaries of M&E officers, equipment for data processing, communications, and transportation as well as the costs of data collection. Data collection costs include HIV and behavior surveillance as well as the collection and processing of service statistics.

Strategic communication

Funding related to strategic communication is primarily personnel costs for preparing analyses and presentations, conducting awareness-raising and policy dialogue with opinion leaders, policy makers and stakeholders. Additional costs include office support costs, and transportation and materials production associated with dissemination activities.

Logistics

Logistics system costs include the costs of procurement, transportation, storage, testing and distribution of commodities such as ARV drugs, other essential drugs, test kits, gowns, gloves and masks. The costs of the materials themselves (condoms, ARV drugs, etc.) are not included here but in the unit costs of providing those services.

Program-level HR

Costs for program-level human resource management are all costs at the above-facility level associated with managing human resources (e.g., compensation, benefits, recruitment, etc.) except those associated with training, which is a separate category.

Training

Training costs may include both pre-service and in-service training for health care workers as well as special training for program staff in areas such as strategic planning, M&E, advocacy, and financial and reporting systems.

Laboratory equipment

Costs associated with laboratory equipment acquired at the central, or above-facility, level.

7.6.4.5   Mitigation

Programming for orphans and vulnerable children varies enormously by country, both in terms of target population and type of programs. Orphans are defined as children under the age of 18 who have lost one or both parents; an AIDS orphan is a child under 18 who has lost one or both parents to AIDS. In general, programming for orphan support should not distinguish between AIDS and non-AIDS orphans, as both need education, food, clothing, etc. In addition, many other children may be vulnerable and in need of support. Definitions of vulnerability vary from country to country, so the number of orphans and vulnerable children potentially in need of support will depend on national definitions.

In countries with generalized HIV/AIDS epidemics a significant proportion of orphans are due to AIDS. As a result orphan support is often included as part of the HIV/AIDS budget. In other countries, AIDS may be responsible for only a small percentage of all orphans. In those cases, orphan support may not be considered part of the AIDS budget and this section can be skipped.

Estimates of the number of orphans by age, both AIDS and non-AIDS, are available in the AIM module. Note that not all orphans are in need of public support; for example, some may be living with one surviving parent who can afford to care for them. One possible definition is to estimate the proportion of orphans in need of public support as the proportion of households living below the poverty line, while another is to estimate the proportion of orphans in the lowest two wealth quintiles. Orphans and vulnerable children need many types of support including education, food, health care, shelter, clothing, economic support and psychosocial support. There has been a shift in recent years to providing support through cash transfer programs rather than direct material support; both UNICEF and PEPFAR have guidance with recommended programs.

Because countries have such different programmatic approaches, the RNM provides an input screen which can be used to enter multiple programs, each with a total budget across the timeframe of the analysis in either US dollars or the local currency. Programs that have been added can also be deleted at a future point, if necessary.

[1]PEPFAR. Guidance for Orphans and Vulnerable Children Programming, July 2012; and UNICEF, Taking Evidence to Impact: Making a Difference for Vulnerable Children Living in a World with HIV and AIDS, 2011.

7.6.5   Projection results

The RNM module calculates and displays different variables organized into the sections *Resources required, Number of people reached, Adult treatment costs,* and *child PMTCT and treatment costs.* The variables are listed below; most of the intervention definitions are in the Projection Input chapter immediately above, while the equations used in calculations are provided in the Methodology chapter.

7.6.5.1   Resources required

Resources required summary. The total resources required, by year, for each of the interventions for which data were entered, including any additional populations, support functions, or mitigation activities that were added. The core interventions that are displayed (along with subtotals) are:

Prevention (subtotal)

Priority populations

- **Youth-focused interventions:** Sum of in-school and out-of-school youth programs

- **Female sex workers and their clients:** Cost of outreach programs targeting FSW and their clients
- **Male sex workers and their clients:** Cost of outreach programs targeting MSW and their clients
- **Workplace:** Sum of peer education programs and STI treatment in the workplace
- **Injecting drug users:** Cost of five separate programs targeting IDU
  - IDU harm reduction
  - IDU testing and counseling
  - IDU community outreach and peer education
  - IDU needle and syringe exchange
  - IDU drug substitution
- **Men who have sex with men:** Cost of outreach programs targeting MSM
- **Community mobilization:** Cost of community mobilization programs

Service delivery
- **Condom provision:** Cost of condoms provided by the public sector
- **STI management:** Cost of STIs treated in clinics
- **Voluntary counseling and testing:** Cost of VCT programs, regardless of service delivery mode
- **Adult male circumcision:** Cost of adult male circumcision, including both traditional and medical circumcisions
- **Early infant male circumcision:** Cost of early infant male circumcision
- **PMTCT:** Cost of programs to prevent mother-to-child transmission, including ARVs and VCT
- **Mass media:** Cost of mass media interventions

Health care
- **Blood safety:** Cost of testing units of blood for (only) HIV
- **Post-exposure prophylaxis:** Sum of PEP kits for rape victims and needle sticks and other medical injuries
- **Safe injection:** Safe medical injections for immunizations and other medical treatments
- **Universal precautions:** Cost of providing universal precautions

Care and treatment services (subtotal)
- **ARV therapy:** Sum of commodities and service delivery costs for ART for adults and children (can be displayed in further detail in other sections – see below)

- **Non-ART care and prophylaxis:** Sum of commodities and service delivery costs for non-ART care and prophylaxis for adults and children (can be displayed in further detail in other sections – see below)

Program support (subtotal)

- Enabling environment
- Program management
- Research
- Monitoring and evaluation
- Strategic communication
- Logistics
- Program-level HR
- Training
- Laboratory equipment

Mitigation (subtotal)

- **Various programs:** Cost as entered in the Input tab for mitigation programs

Total *Sum of all prevention, care and treatment, and mitigation interventions and program support costs*

7.6.5.2 Number of people reached

Number of people reached summary. These are the number of people reached, or other service provided, by year, corresponding to the interventions listed in the prevention, care and treatment, and mitigation (when included) services above under Resources Required.

Prevention

Priority populations

- **Youth-focused interventions:** Number of youth reached by in-school and out-of-school youth programs

- **Female sex workers and their clients:** Number of female sex workers reached by outreach programs

- **Male sex workers and their clients:** Number of male sex workers reach by outreach programs

- **Workplace:** Number of employees reached by interventions in the workplace

- **Injecting drug users:** Number of IDU reached by one or more of the five programs listed
    - IDU harm reduction

- o IDU testing and counseling

- o IDU community outreach and peer education

- o IDU needle and syringe exchange

- o IDU drug substitution

- **Men who have sex with men:** Number of MSM reached by outreach programs

- **Community mobilization:** Number of people reached by community mobilization programs

Service delivery
- **Condom provision:** Number of condoms distributed by the public sector

- **STI management:** Number of STIs treated in clinics

- **Voluntary counseling and testing:** Number of people receiving VCT services

- **Male circumcision:** Number of traditional and medical male circumcisions performed

- **PMTCT:** Number of women receiving PMTCT services

- **Mass media:** Number of people reached by mass media campaigns

Health care
- **Blood safety:** Number of blood units screened for HIV

- **Post-exposure prophylaxis:** Number of PEP kits distributed

- **Safe injection:** Number of medical injections utilizing AD syringes

- **Universal precautions:** Number of hospital beds utilizing universal precautions

Care and treatment services
- **ARV therapy:** Number of adults and children receiving first- and second-line therapy (can be displayed in further detail in other sections – see Adult treatment costs)

- **Non-ART care and prophylaxis:** Number of adults and children receiving non-ART care and prophylaxis (can be displayed in further detail in other sections – see below)

Note that it is not possible to display the population reached by mitigation interventions, as only total resources required are entered for those interventions.

7.6.5.3 Adult treatment costs

The indicators displayed in this section show the disaggregated costs associated with adult care and treatment costs, including ART, non-ART, and prophylaxis costs.

- **First-line ARV:** The cost of ARV drugs for adults on first-line triple therapy.

- **Second-line ARV:** The cost of ARV drugs for adults on second-line triple therapy.

- **TB-ARV:** The incremental cost of ARV drugs required when an adult is co-infected with TB.

- **Lab tests:** The cost of laboratory monitoring for adults on ART.

- **OI treatment:** The cost of drugs and laboratory tests associated with treating adults with OIs.

- **Cotrimoxazole:** The cost of providing cotrimoxazole to adults.

- **TB prophylaxis:** The cost of providing TB prophylaxis to adults.

- **Nutrition:** The cost of providing nutritional supplements to adults.

- **First-line service delivery costs:** The service delivery cost of providing first-line ARVs to adults.

- **Second-line service delivery costs:** The service delivery cost of providing second-line ARVs to adults.

- **OI treatment service delivery costs:** The service delivery cost of providing OI treatment to adults.

- **Summary costs:** A table showing all costs by type and year, with a total cost indicator at the bottom.

7.6.5.4 Child PMTCT and treatment costs

- **PMTCT costs:** The total cost of the PMTCT program, including counseling, testing and ARVs for both mothers and children.

- **Child treatment costs:** The cost of providing ART to children, including drug costs, lab tests and service delivery costs.

- **Total child treatment costs:** The sum of PMTCT and child treatment costs.

- **PMTCT benefit-cost ratio:** The ratio of the benefits of the PMTCT program (calculated as the ART costs saved due to the averted infant infections) to the costs (calculated as the total costs of the program, above).

- **Summary Table:** A table showing all costs by type and year.

7.6.6 Program tutorial

7.6.6.1 Overview

This tutorial covers the key steps in installing and running Spectrum and RNM. It assumes you have a computer running Windows XP and above and that you are familiar with the basic operation of Windows programs and terminology.

7.6.6.1.1 Before you get started

You will need to collect data and make certain decisions before running the model. For approximately 60 low- and middle-income countries, default values are available for RNM based on workshops sponsored by UNAIDS in 2010[1]. There are default data for all countries for DemProj, and most countries for AIM, both of which are required to run RNM.

[1] Futures Institute, "Financial Resources Required to Achieve National Goals for HIV Prevention, Treatment, Care and Support," Glastonbury, CT: June 2010.

7.6.6.1.2 Installing the program

The OneHealth program is available at: http://www.AvenirHealth.org. It must be installed on a hard disk before it can be used. OneHealth will operate on any computer running Windows XP and above. It requires about 62MB of hard disk space.

To install the OneHealth program, start your internet browser and go to http://www.AvenirHealth.org. Click on "Software" and then "OneHealth." There are usually several versions of OneHealth available, as sometimes a specific version is required for a particular application. Click on the version that is labeled "Latest release" (unless you want a different version). From the dialogue box that appears next, select "Save." Select a location for the file. Once the file has been downloaded, click on that file and then follow the instructions.

The OneHealth model is updated frequently throughout the year, so you should check back periodically to ensure you have the most up-to-date version.

7.6.6.2   Creating a new projection

7.6.6.2.1 Starting the Spectrum program

To start OneHealth:

1.   Click the "Start" button on the task bar.

2.   Select "Programs" from the pop-up menu.

3.   Select "OneHealth" from the program menu. Alternatively, you can use Windows Explorer to

locate the directory "c:\OneHealth" and double click on the file named "OneHealth.exe."

7.6.6.2.2 Opening a new projection for RNM

RNM in OneHealth requires a demographic projection prepared with DemProj and an HIV/AIDS projection prepared with AIM. Before using RNM, you should use DemProj to prepare a demographic projection, and AIM to prepare an HIV/AIDS projection. Both modules are part of the Spectrum System of Policy Models. In a typical RNM application, the demographic projection calculates all the normal demographic processes (births, deaths, migration, aging). AIM influences the demographic projection by adding the number of AIDS deaths and, possibly, specifying a lower fertility rate because of the effects of HIV infection. All of the population figures required by RNM (e.g., size of the adult population) are provided by DemProj, while HIV/AIDS-related data are provided by AIM. For more information on DemProj, consult the DemProj Manual for Spectrum that is a companion to this one, *DemProj: A Computer Program for Making Population Projections*, while for AIM you should consult *AIM, A Computer Program for Making HIV/AIDS Projections and Examining the Demographic and Social Impacts of AIDS*. Both are available online at http://www.AvenirHealth.org.

One easy way to create a projection is to use the default values discussed above, based on the UNAIDS-sponsored workshops. To use this feature, follow these steps:

1.   Select "New projection" from the Welcome screen (shown below). You can also select either "New projection" from the File tab in the upper left-hand corner of your screen, or "New" when "Home" is selected on the menu bar that runs across the top of the screen (shown below).
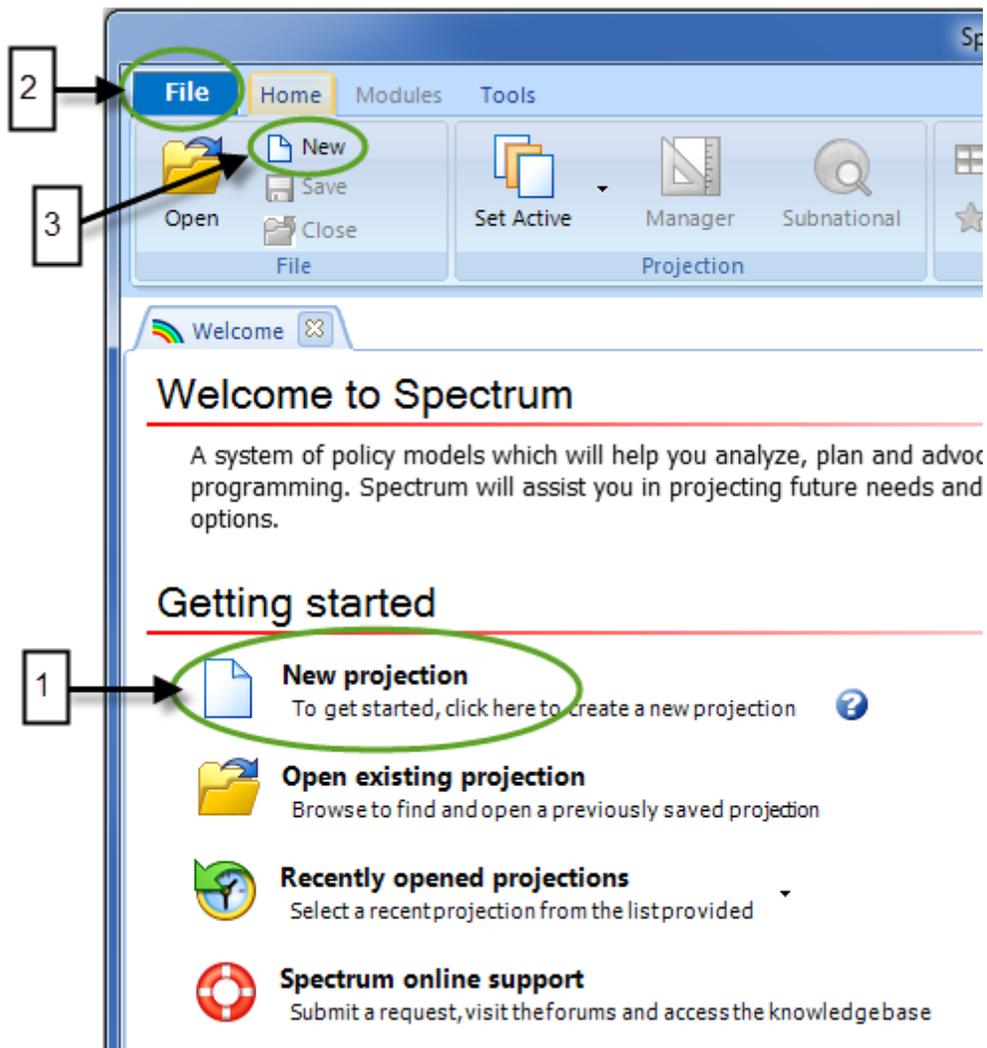
2. You will see the Projection Manager dialogue box. It will look similar to the display shown below:
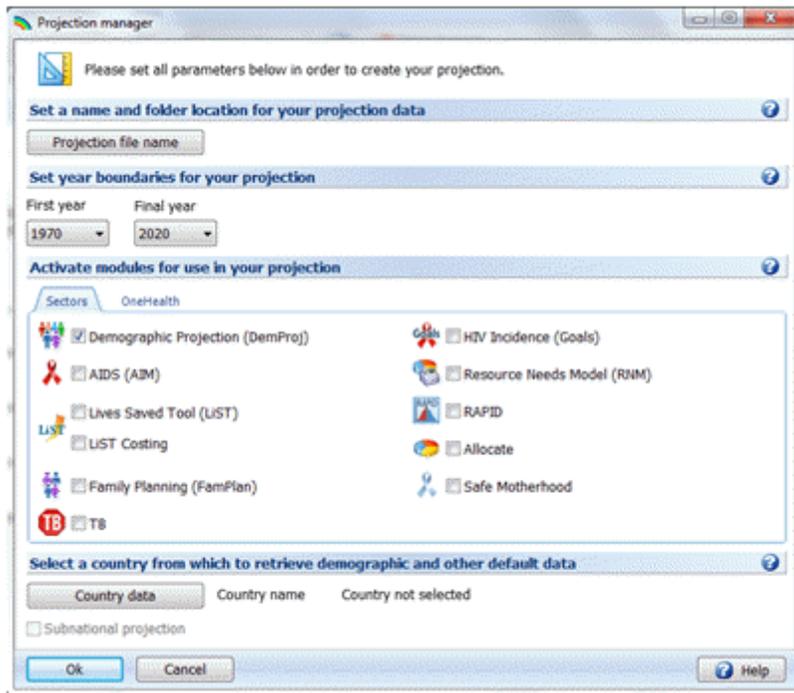
3. Click on "Projection file name", select the folder where the projection files will be located, and then type in a file name. This file name will be printed at the top of all printed output and will be used to identify the projection if more than one projection is loaded at a time. Note that you can only change the file name by selecting "File" and "Save projection as" from the application button in the upper left-hand corner of your screen to save the projection to a new name. If a box is shown in gray, you will not be able to change its contents. It means that a projection has been loaded, and the data must remain the same. If you want to create an entirely new projection, you should close the other projections, using "Close", and then select "File" and "New". Users may want to have several projections open in order to examine the effects of changing assumptions.

4. Click on the arrow under the "First year" label, and select the first year that you want to cost in the projection.

5. Click on the arrow under the "Final year" label, and select the final year that you want to cost in the projection.

6. The "Active modules" section has check boxes that let you select other modules that will be used with the population projection. Check the box next to "Resource Needs Model (RNM)"; Spectrum will then automatically check the box next to "AIDS (AIM)", as it is required in order to run RNM. DemProj is always selected for any projection, so it is checked from the beginning.

7. As discussed above, there are default data for the RNM module for approximately 60 low- and middle-income countries. Clickon the Country Data tab, which will then display a list of countries. On the right, you will see a box that shows when default data are available for a country for the modules you have selected (DemProj, AIM and RNM). When data are not available, the module name is grayed out and has a red asterisk, indicating that default data are not available. Note that if data are not available for your country, you could examine default data for a similar or neighboring country, particularly with respect to unit costs. The demographic data are the most recent data prepared by the United Nations Population Division, and by default the projection will use the UN medium variant

assumptions for base year population, the total fertility rate, and for male and female life expectancy. The default data for the HIV/AIDS epidemic are the updated data from biennial country-specific workshops run by UNAIDS. Note that we will use default values for Ghana in this tutorial. Once all the information is entered for this dialogue box, click on the "OK" button. You can always return to this screen and change some of the information by selecting "Edit" from the menu bar and then "Projection" from the pull-down menu.

8. Click "OK" to return to the dialogue box and click "OK" once more to complete the set-up process.

9. Select "File" and "Save projection" from the application button to save this projection.

10. You can then click on "Modules" on the menu bar, and then click on "RNM" to begin working in RNM.
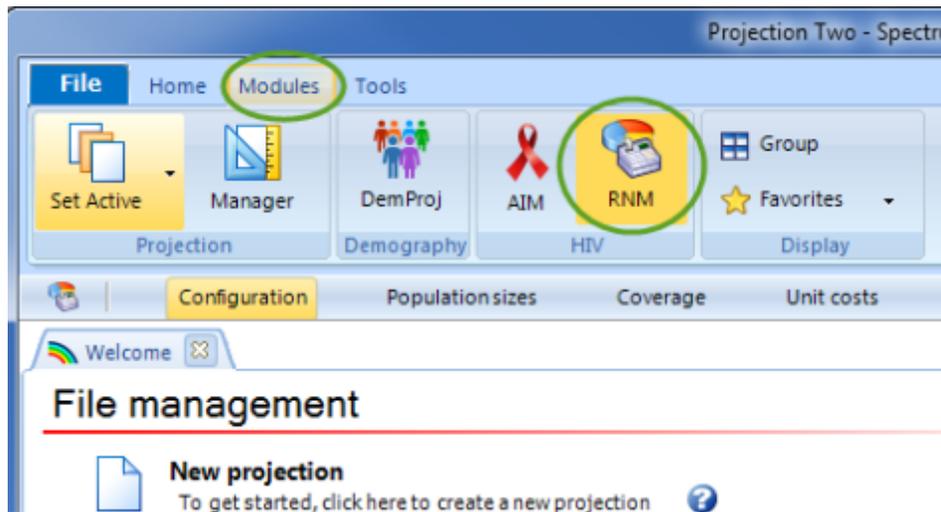
7.6.6.3 Saving the projection

It is always a good idea to save the projection whenever you make a change to any assumptions. To save the projection without changing the name, choose "Save projection" from the application button, or select "Save" from the set of file commands displayed when "Home" is selected on the menu bar.

To save the projection with a different name, choose "File" from the application button and then "Save projection as". You will then have a chance to specify a new file name for the projection.

7.6.6.4 Opening an existing projection

If you have already created an RNM projection or are using a projection provided by someone else, you can immediately load that projection.

1. Select "Open existing projection" from the Welcome screen. Alternatively, you can select "Open projection" using the application button or "Open" when selecting "Home" from the menu bar.

2. Select the file you wish to use and click the "OK" button to open the projection.

You can open more than one projection at a time. Simply repeat these steps to load a second, third, or even up to 10 projections. When you have more than one projection loaded, all projections will be displayed in the graphs and tables.

When you have more than one projection loaded, the active projection is listed at the bottom of the screen in bold font, with an asterisk. To change the active projection, click on the "Set Active" button when selecting either "Home" or "Modules" on the menu bar. The program will display a list of the projection names and you may choose the appropriate one from the list.

7.6.6.5   Closing a projection

To close a projection that has already been opened,

1. Choose "Close projection" from the application button or click on "Close" when "Home" is selected on the menu bar. If you have more than one projection loaded, you will be asked to select which projection should be closed.

Closing a projection merely removes it from the computer's memory; it does not erase it from the hard disk. You can open that projection again at any time.

7.6.6.6   Entering the projection inputs using editors

For readers who feel they need additional review or explanations of the terms found in this section, RNM input editors and the glossary for RNM may be useful.

7.6.6.6.1 Editor screen format

The editors are similarly formatted screens which allow you to enter and/or edit the inputs on which a projection is based. The buttons at the bottom of the screen can be used to save the inputs (click on "OK"), cancel the most recently typed data (click on "Cancel"), or supply background information (click on "Source" and then type in the box that appears). The Source feature allows you to keep a record of the data sources and assumptions as you make the projections. This source information will be maintained with the data file and printed whenever you print the projection summary. It is **strongly** recommended that you use this feature to avoid later confusion.

Special functions can be accessed by highlighting one or more input cells and then right-clicking on your mouse. Besides the usual commands ("Undo", "Redo", "Cut", "Copy", "Paste" and "Copy All"), there are several other functions available. "Duplicate" allows you to copy information from one cell, column, or row to another; highlight (select) the range of cells, with the first cell being the value you want to copy, and then drag the mouse to extend the range to the last year. You can use "Interpolate" to enter a beginning and ending number in the appropriate cells and have the computer calculate the numbers for the intervening intervals using different patterns: linear, S-shared, exponential, or front-loaded. Finally, you can control the formatting of the cells by either increasing or decreasing the number of decimal places shown, or choosing to display the thousands separator.

Note that on a few input screens there are extra buttons to add or delete programs; these will be discussed further below.

7.6.6.6.2 Organization of the editor screens

The editor screens are organized by input variable, each of which is labeled on a tab at the top of the editor, and one tab to display Results. The editor for that variable is brought to the foreground when its tab is clicked on, and it becomes active when the actual editor screen is clicked on. When there are a number of tabs, a dropdown menu appears in the right-hand corner; click on the arrow to move between tabs.

There are six Input tabs and one Results tab; instructions on how to access and utilize the dialogue box, the variable groupings, and the editors for each variable follows.

7.6.6.7 Configuration

1. After selecting "Modules" from the menu bar and then clicking on "RNM", choose "Configuration" from the module menu bar. The screen below will appear.
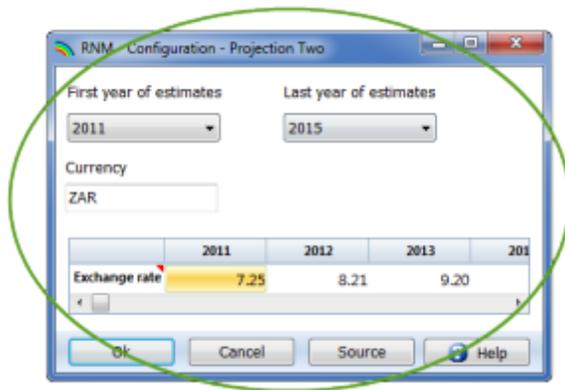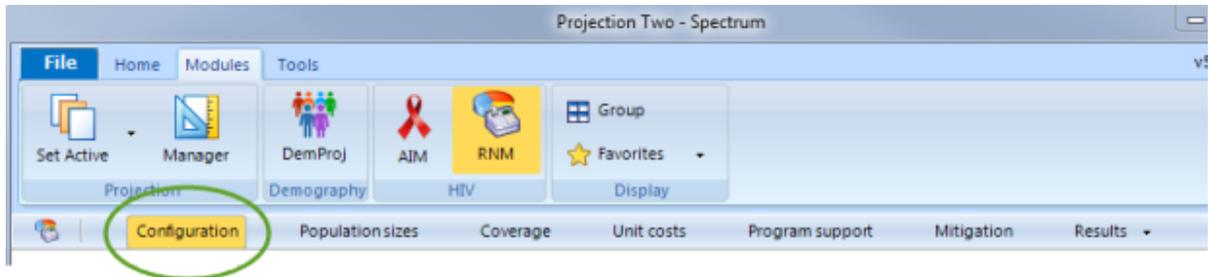
2. Click on the arrow to the right of "First year of estimates" to display the dropdown menu, and select the first year.

3. Click on the arrow to display the dropdown menu for the "Last year of estimates", and select the last year.

4. Type in the "Exchange rate" (relative to the US dollar) you will use. The default value shown here is for Ghana cedis in 2012.

5. Type in the abbreviation you will use when displaying results in the local currency. The value here is GHS, the abbreviation for Ghana cedis.

7.6.6.8 Population sizes

1. Click on "Population sizes" from the module menu bar. There are four tabs within this screen (see below); you can move between tabs by clicking on a tab, or by using the dropdown menu at the right-hand side of the screen and choosing a tab (circled below).
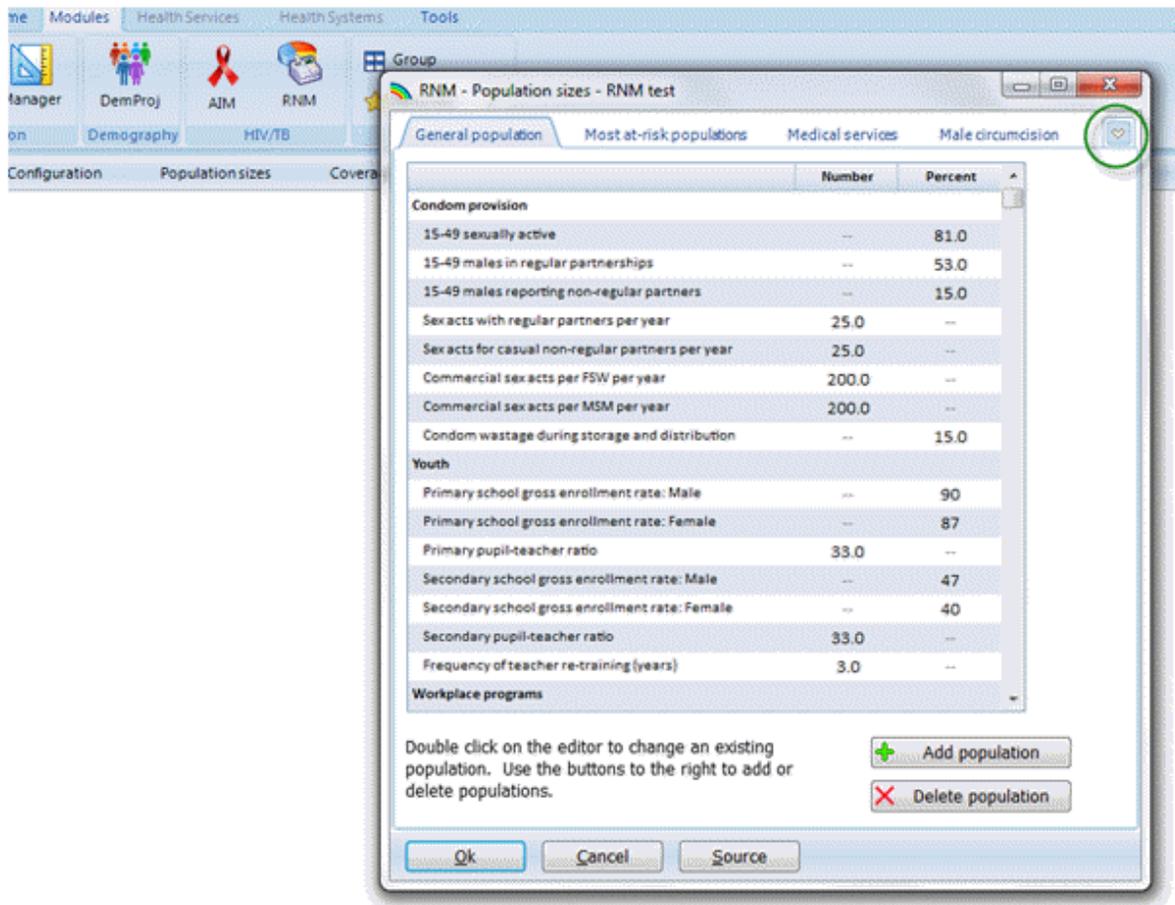
7.6.6.8.1 General population

1. Click on the General Population tab. You can either enter data or change the default values (if supplied) by clicking on the cell with data; for example, click on the "Percent" cell for 15-49 sexually active to change that value. The type of value, either number or percent, is pre-determined and cannot be changed.

2. You can add other general population groups by clicking on the button labeled, "Add population". The following screen will appear:
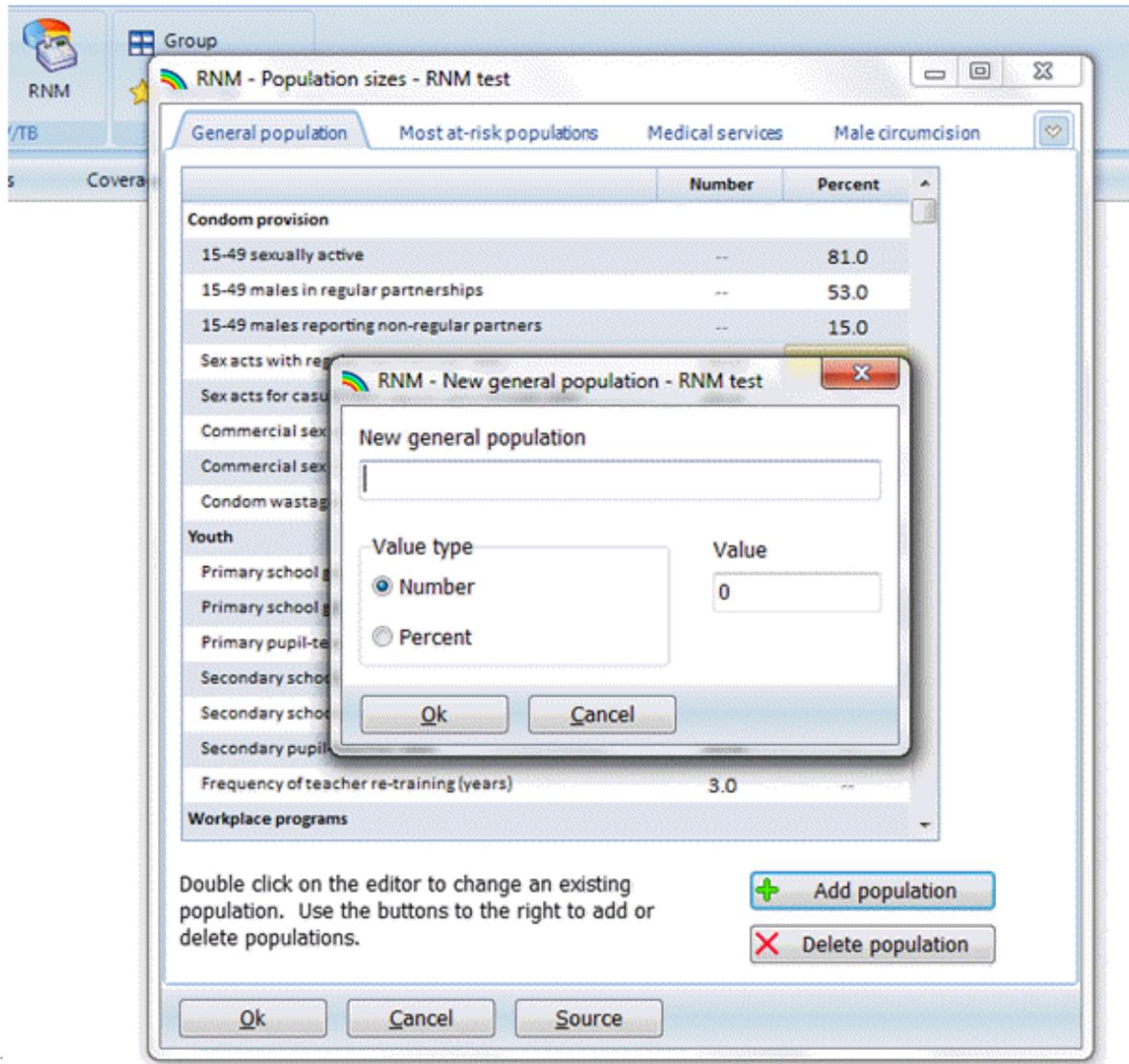
Type in a label for the new general population group, and select the appropriate radio button regarding whether the value will be a number or a percent. Then type in the value, and click "OK" to save your entry. You may cancel adding the population group by clicking on "Cancel".

The new population group will appear in blue font. Once entered, it will also appear automatically in the "Coverage" and "Unit cost" General Population tabs. You may delete the group by clicking first on the group, and then on the "Delete population" button.

3. Make sure to click on the arrow at the bottom of the input screen to see all of the input data categories (circled below). For the General Population tab, data for Workplace programs and Violence against women will appear after scrolling down. This is also where any added population groups will appear.
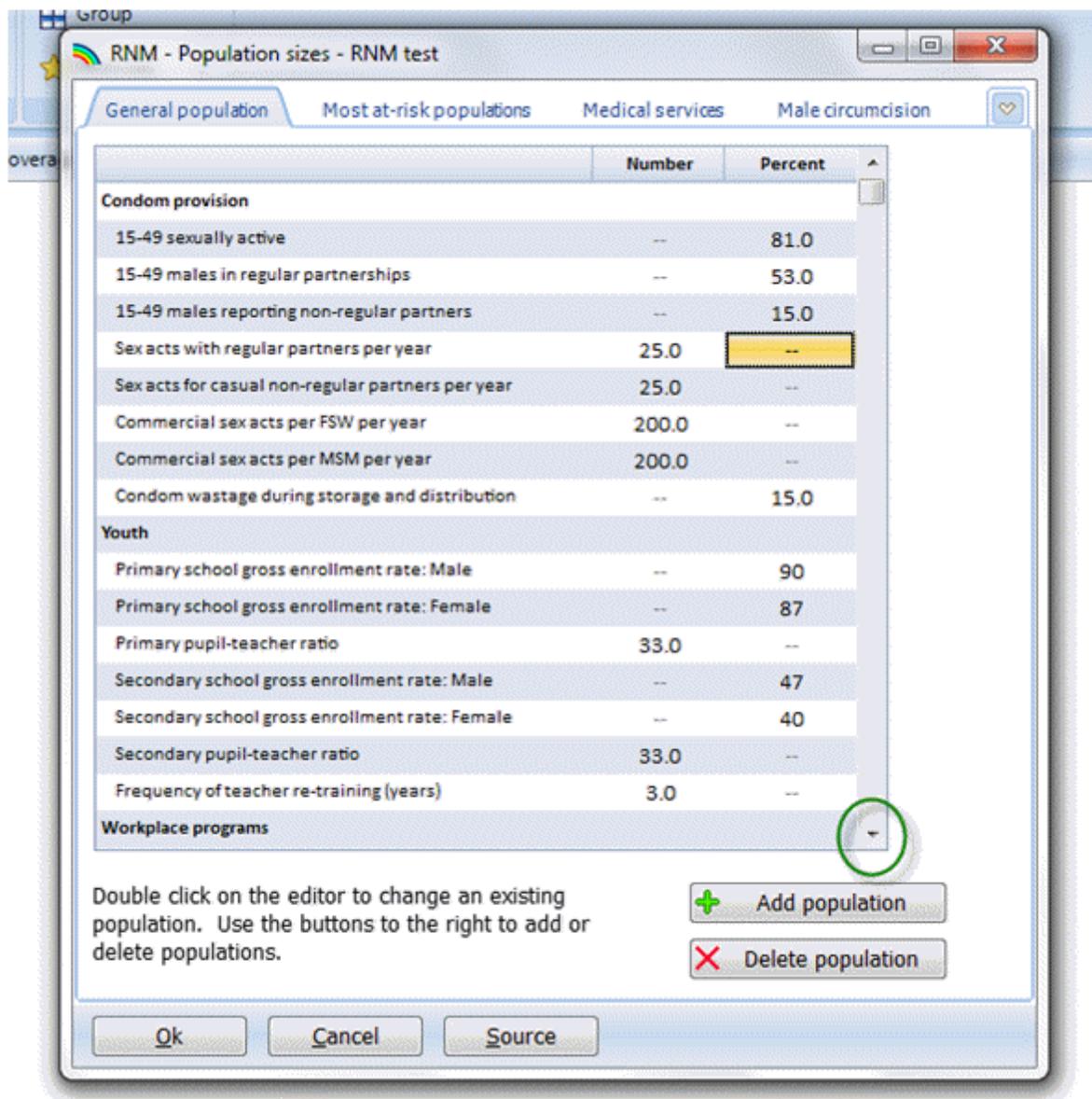
7.6.6.8.2 Most-at-risk populations

1. Click on the Most At-risk Populations tab. You can either enter data or change the default values (if supplied) by clicking on the cell with data; for example, click on the "Number" cell for Female sex workers in the screen below. Data for most-at-risk populations can be entered using either a number or a percent.
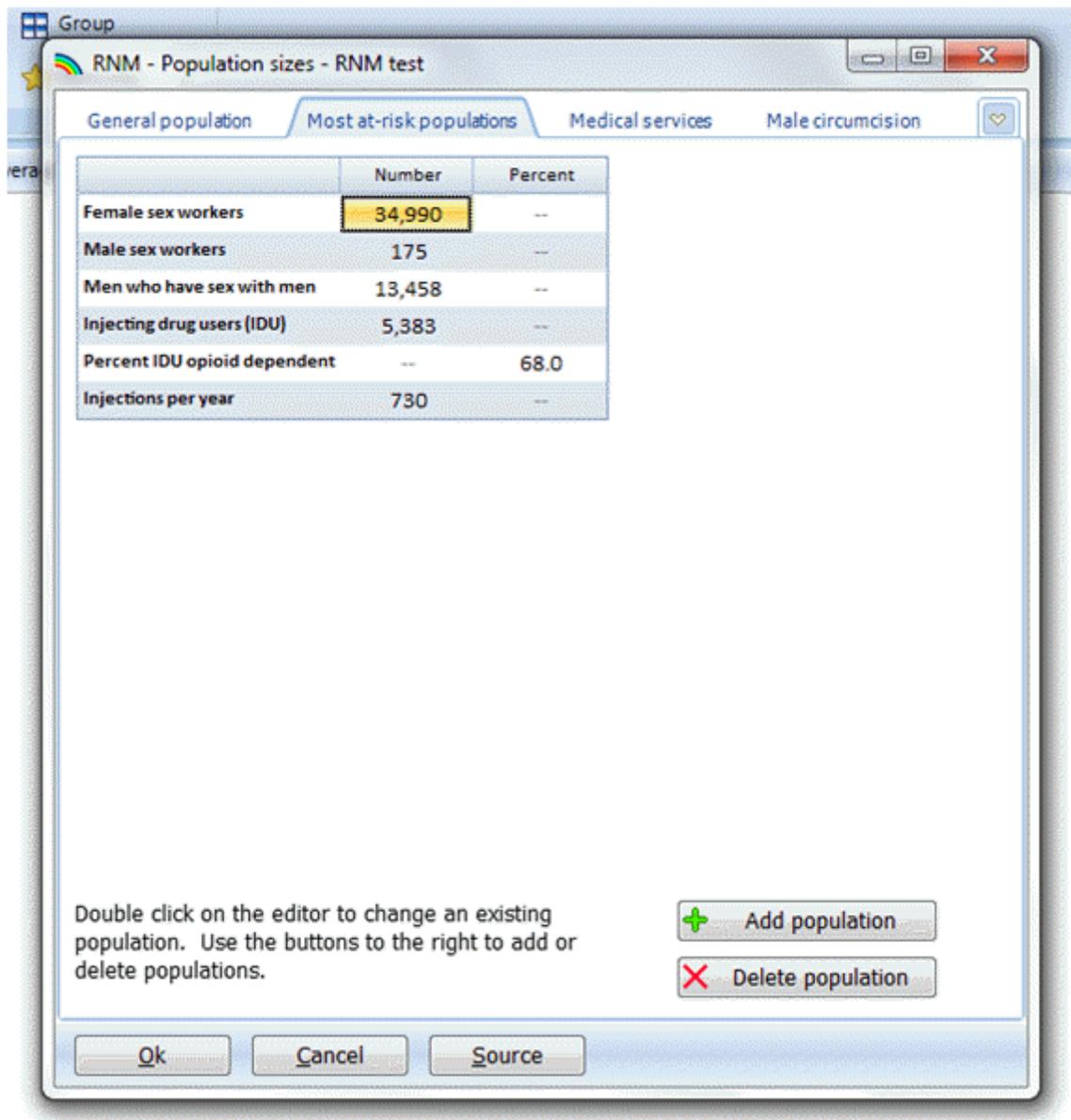
2. You can add other most-at-risk populations by selecting the "Add population" button; a similar dialogue box will appear as did for general populations. To add a most at-risk group, for example, truck drivers, type in the label, choose whether the value will be a number or a percent, and then enter the value.
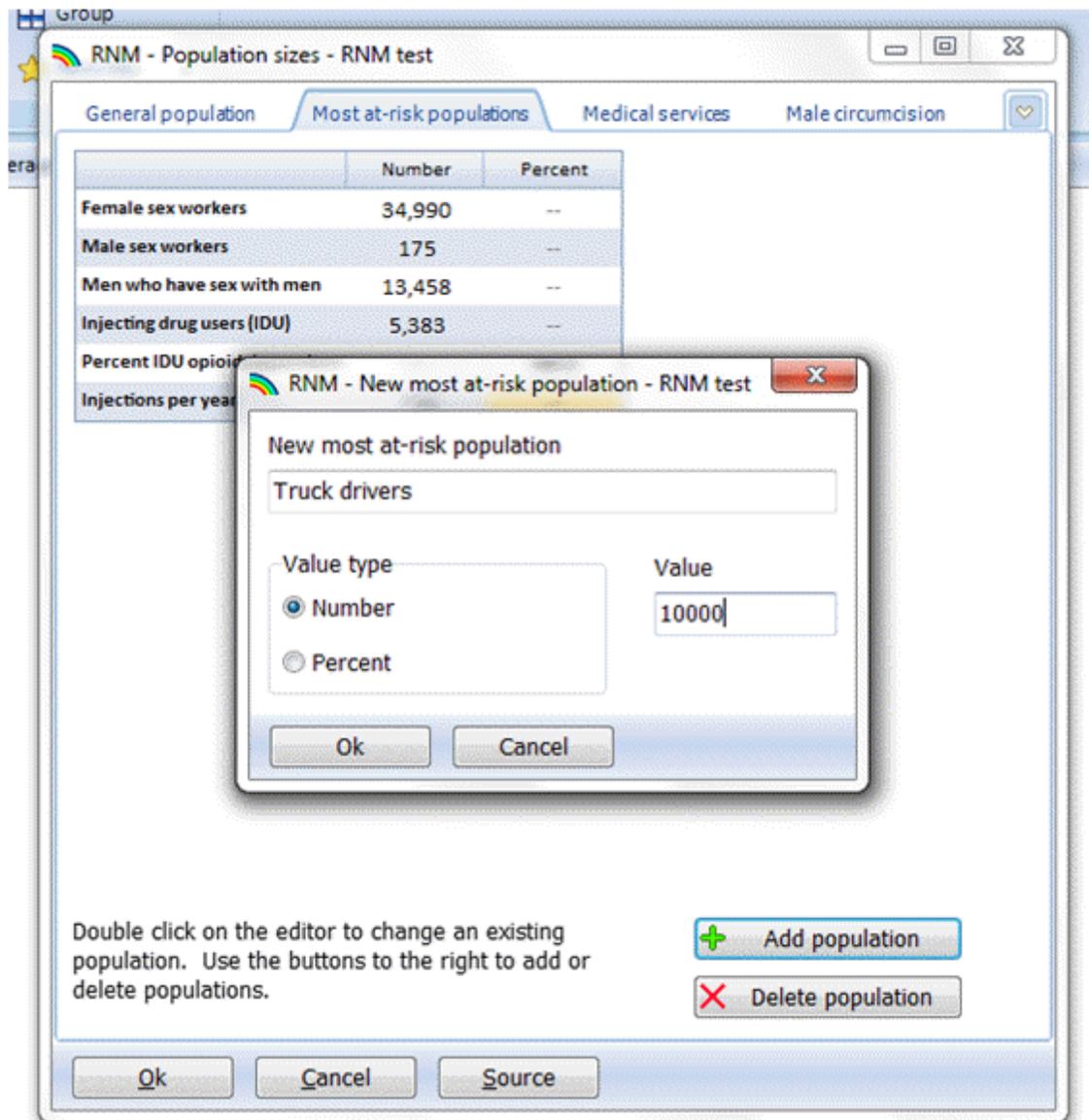
3. After you have finished, click on the "OK" button. The new population will appear in blue.

4. You can delete any of the added populations by first selecting the population, then clicking on the "Delete population" button.

7.6.6.8.3 Medical services

1. Click on the Medical Services tab. The following screen will appear.

RNM - Population sizes - RNM test

General population	Most at-risk populations	Medical services	Male circumcision

	Number	Percent
STI management		
New cases of treatable STIs: male (incidence)	384,720	--
New cases of treatable STIs: female (incidence)	111,512	--
STIs that are symptomatic: Male	--	60.0
STIs that are symptomatic: Female	--	40.0
Blood safety		
Blood units required per 1,000 people	3.2	--
Post-exposure prophylaxis		
PEP kits required per million population	50.0	--
Safe medical injection		
Average number of immunizations per child 0-23 months	10.0	--
Adult injections per person per year	2.2	--
Injections that are unsafe	--	2.0
Universal precautions		
Hospital beds per 1000 population	1.5	--

Ok	Cancel	Source

2. Either type in values or confirm the default values. The type of each variable here is pre-defined as either a number or a percent, and cannot be changed. Also, note that no additional populations can be added for this group of interventions.

7.6.6.8.4 Male circumcision

1. Click on the Male Circumcision tab. The following screen will appear.

2. Enter the percent of adult males who are currently circumcised by either medical or traditional methods. No other interventions may be added on this screen.

3. Click on "OK" to save the data you have entered for the various Population sizes and to exit this series of input screens. Note that clicking the "Cancel" button will cancel *all* of the data entries that you have made for Population sizes.

7.6.6.9   Coverage

1. Click on "Coverage" from the module menu bar. There are five tabs within this screen (see below); as with Population groups, you can move between tabs by clicking on a tab, or by using the dropdown menu at the right-hand side of the screen and choosing a tab (circled below).

7.6.6.9.1 General population

This tab allows you to enter base year and target year coverage rates for the prevention interventions targeting the general population. Note that these labels are different than the labels in the "Population sizes" input screens, as the interventions use different components of the population-related inputs in the final calculations (see the RNM input editors section for descriptions of the interventions, and the Methodology section for a complete description of the equations used).

1. Click on the cell for Base year for each intervention and enter a value. If you have used default values and you want to change them, click on the cell that you want to change and enter the new value.

2. Click on the cell for Target year for each intervention and enter a value. If you have used default values and you want to change them, click on the cell that you want to change and enter the new value.

3. By default, a linear pattern is used to interpolate coverage rates between Base year and Target year. You can see the intervening coverage rates, and change them if you like, by clicking on the "Expand" button at the bottom of the screen (circled below).

The coverage rates for all of the years are now displayed. In the example below, you can see the linear interpolation that the RNM uses to calculate the intervening coverage rates between Base year and Target year. You may change any coverage rate by clicking on the cell and entering a new value.

4. To collapse the columns back to the original display, click on the "Collapse" button at the bottom of the screen (circled below):

7.6.6.9.2 Most-at-risk populations

1. Click on the Most At-risk Populations tab. This tab allows you to enter base year and target year coverage rates for the prevention interventions targeting most-at-risk populations (see the RNM input editors section for descriptions of the interventions, and the Methodology section for a complete description of the equations used). Note that the population added before, Truck drivers, is listed in blue font at the bottom of the screen.

2. Click on the cell for Base year for each intervention and enter a value. If you have used default values and you want to change them, click on the cell that you want to change and enter the new value. You will have to enter a percent coverage rate (between zero and 100) for any population groups that have been added.

3. Click on the cell for Target year for each intervention and enter a value. If you have used default values and you want to change them, click on the cell that you want to change and enter the new value. You will have to enter a percent coverage rate (between zero and 100) for any population groups that have been added.

4. Again, a linear pattern is used to interpolate coverage rates between Base year and Target year. Click on the "Expand" button to see coverage rates for intervening years, and make any changes by clicking on the cell to be changed.

5. Click on the "Collapse" button if you want to hide the coverage rates for the intervening years.

7.6.6.9.3 Medical services

1. Click on the Medical Services tab. Here you can enter the Base year and Target year coverage rates for interventions provided through the medical sector (see the RNM input editors section for descriptions of the interventions, and the Methodology section for a complete description of the equations used).

2. Enter or change Base year coverage rates by clicking on the relevant cell and entering a percent. All values should be in percent form (between zero and 100). Note that the coverage rate should reflect the fact that STI treatment is provided to men and women with symptomatic STIs.

3. Enter or change Target year coverage rates by clicking on the relevant cell and entering a percent. All values should be in percent form (between zero and 100). Note that the coverage rate should reflect the fact that STI treatment is provided to men and women with symptomatic STIs.

4. To see the coverage rates that have been linearly interpolated by the program, click on the "Expand" button at the bottom of the screen. Click on any cell to change its value.

5. To return to the original display of only Base year and Target year, click on the "Collapse" button.

7.6.6.9.4 Male circumcision

1. Click on the Male Circumcision tab. Here you can enter the Base year and Target year coverage rates for adult and early infant male circumcisions, including both traditional and medical male circumcisions. Note that, if the population is growing, keeping coverage constant will result in some circumcisions. Also note that coverage must be entered beginning in 1990, so that HIV infections can be calculated correctly.

2. Enter or change coverage rates by clicking on the relevant cell and entering a percent. All values should be in percent form (between zero and 100). Recall that you may use one of the built-in editor functions (Duplicate, Interpolate, etc.) to fill in values by right-clicking on the cell and selecting from the dropdown menu.

7.6.6.9.5 Treatment

1. Click on the Treatment tab. There are two steps in identifying the adults who will receive ART.

2. First, specify the CD4 count below which an adult or adolescent will be eligible for ART. This criterion must be entered beginning in 1990, in order to calculate HIV infections accurately. The eligibility threshold will probably change over time; the values in the screen below reflect how the WHO guidelines have changed over time, beginning with 200 in 1990, changing to 350 in 2010, and changing again to 500 in 2013.

3. Click on the cell you want to change, and enter the new value. Recall that you may use special editing functions (Duplicate, Interpolate, etc.) to fill in values by right-clicking on the cell and selecting from the dropdown menu.

4. Second, you must select which method you will use to enter ART coverage. If you want to use data on either the number of adults receiving ART or the percent of adults receiving ART (with the denominator being adults needing ART), click on the radio button next to "Number or percent" (see screen below).

5. Enter either the number or percent of males and females receiving ART for each year. Although the editor begins in 1990, it is likely that ART coverage does not begin until the early 2000s; above, coverage in Ghana began in 2003. Note that you can vary the unit of the value entered (number or percent); see the value for Males in 2004 above. You may enter service statistics (actual numbers) on the number receiving ART for past years and use the target (a percent coverage) from the national strategic plan or universal access plan for the future.

6. If instead you want to specify ART coverage by CD4 count category, click on the radio button next to "CD4 category" (see below):

7. Enter the percent coverage (between zero and 100) for each CD4 count category by clicking on the cell and then entering the value. Recall that you may use special editing functions (Duplicate, Interpolate, etc.) to fill in values by right-clicking on the cell and selecting from the dropdown menu.

   Note that, again, coverage may begin in 1990, although it is unlikely to begin prior to the early 2000s. Coverage can vary within each year by CD4 count.

   Note also that no coverage targets are entered for child treatment; following WHO guidelines, the model assumes all children under the age of five who are HIV+ receive ART.

8. Click on "OK" to save all of the entries in the Coverage tab. Clicking on "Cancel" will cancel all of the entries.

7.6.6.10 Unit costs

Click on "Unit costs" from the module menu bar. There are six tabs within this screen (see below); as with the other groups, you can move between tabs by clicking on a tab, or by using the dropdown menu at the right-hand side of the screen and choosing a tab (circled below).

Also circled at the bottom of the screen above is a dropdown menu where you can choose the display currency. Unit costs can be entered in either US dollars (USD) or another currency (the currency name and exchange rate were entered in the Configuration screen). If you want to enter unit costs in the local currency, here Ghanaian cedis, click on the arrow and choose "GHS"; the default unit costs are automatically calculated and displayed in the new currency:
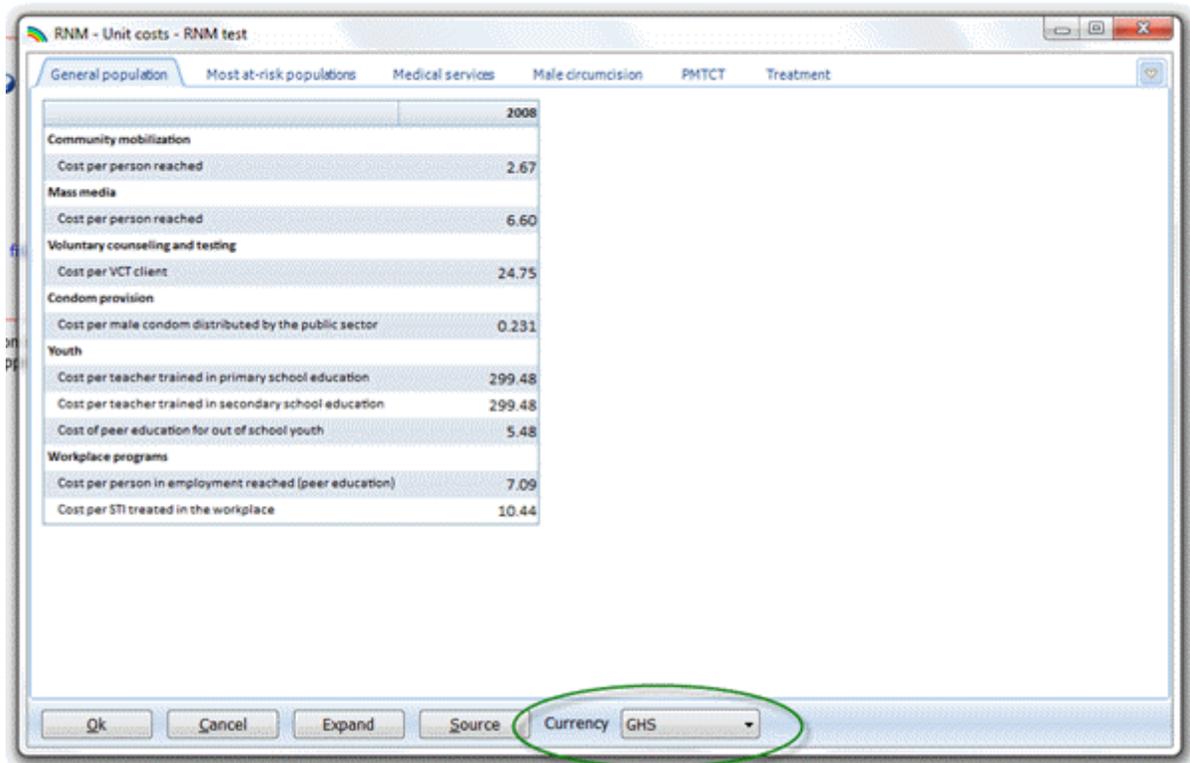
7.6.6.10.1 General population

This tab contains unit cost information for prevention interventions targeting the general population. Although these labels are similar to those in the Coverage tab, they are not exactly alike (see the RNM input editors section for descriptions of the interventions, and the Methodology section for a complete description of the equations used).

1. Click on the cell for the unit cost for each intervention and enter a value. If you have used default values and you want to change them, click on the cell that you want to change and enter the new value. General population groups you have added will appear at the bottom of the input screen.

2. By default, the same unit cost is used for every year. You can see the unit costs for the other years, and change them if you like, by clicking on the "Expand" button at the bottom of the screen, which results in the following screen:

3. If you want to return to the original display, click on the "Collapse" button at the bottom of the screen, circled above.

4. You may change the currency by selecting a different one from the dropdown menu labeled "Currency".

7.6.6.10.2 Most-at-risk populations

Click on the Most At-Risk Populations tab. This tab contains unit cost information for prevention interventions targeting the most-at-risk populations (see the RNM input editors section for descriptions of the interventions, and the Methodology section for a complete description of the equations used).

1. Click on the cell for the unit cost for each intervention and enter a value. If you have used default values and you want to change them, click on the cell that you want to change and enter the new value.

2. Any most-at-risk population groups you have added will appear in blue font at the bottom of the screen; shown below is our example, "Truck drivers". You will have to enter unit cost data for any population groups you have added; no default data are available for these groups.

By default, the same unit cost is used for every year. The screen above displays all of the unit costs, which are displayed by clicking on the "Expand" button at the bottom of the screen.

Note that when unit cost data for the added most-at-risk population group were entered above with the single-year display, the value is automatically duplicated for all years. You can change any value by clicking on the cell and typing in a new value.

3. Click on "Collapse" to change back to the original display of only the first year.

4. You may change the currency by selecting a different one from the dropdown menu labeled "Currency".

7.6.6.10.3 Medical services

Click on the Medical Services tab. The screen below will appear. This tab contains unit cost information for prevention interventions delivered through the medical sector (see the RNM input editors section for descriptions of the interventions, and the Methodology section for a complete description of the equations used).

1. Click on the cell for the unit cost for each intervention and enter a value. If you have used default values and you want to change them, click on the cell that you want to change and enter the new value. If you want to see or enter data for the other years of the projection, click on the "Expand" button. Click on a cell to change the value.

2. You may change the currency by selecting a different one from the dropdown menu labeled "Currency".

7.6.6.10.4 Male circumcision

Click on the Male Circumcision tab. The screen below will appear. This tab contains unit cost information for both adult and early infant male circumcision, both traditional and medical (see the RNM input editors section for descriptions of the interventions, and the Methodology section for a complete description of the equations used).

1. Click on the cell for the unit cost for each intervention and enter a value. If you have used default values and you want to change them, click on the cell that you want to change and enter the new value. If you are providing MC services in a variety of settings, use a weighted average unit cost.

2.   If you want to see or enter data for the other years of the projection, click on the "Expand" button. Click on a cell to change the value. Click on "Collapse" to return to the original display of only the first year.

3. You may change the currency by selecting a different one from the dropdown menu labeled "Currency".

7.6.6.10.5 PMTCT

Click on the PMTCT tab. The screen below will appear. This tab contains unit cost information for a complete PMTCT program, including pre- and post-test counseling, ARV therapy for mother and child, and post-natal counseling and formula feeding (see the RNM input editors section for descriptions of the interventions, and the Methodology section for a complete description of the equations used).

1. Click on the cell for the unit cost for each intervention and enter a value. If you have used default values and you want to change them, click on the cell that you want to change and enter the new value. Note that not all cells in this application have default values, so they must be added.

2. As described in the Input chapter, the unit cost for pre-test counseling will depend on the delivery strategy chosen; it can be performed in individual or groups settings, and by using either opt-in or opt-out strategies. If you hover over the "Pre-test" cell (where there is a red triangle in the upper-right-hand corner), you will see the comment.

3. If you want to see or enter data for the other years of the projection, click on the "Expand" button. Click on a cell to change the value. Click on "Collapse" to return to the original display of only the first year.

4. You may change the currency by selecting a different one from the dropdown menu labeled "Currency".
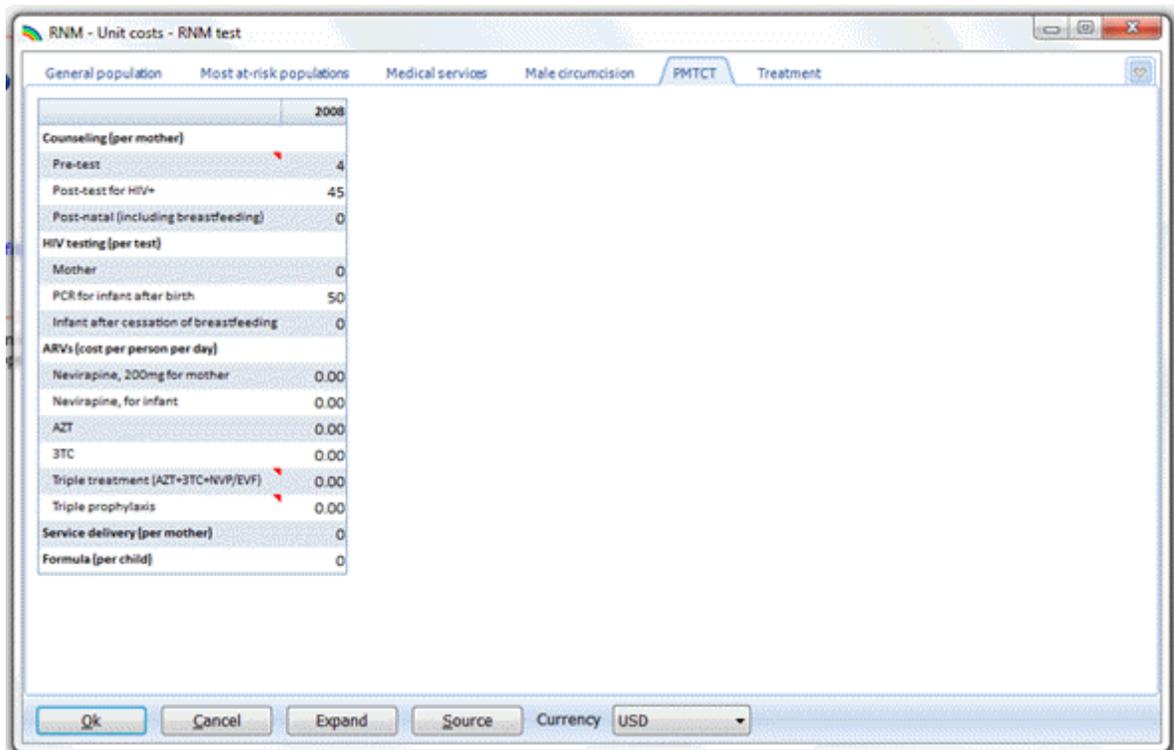
7.6.6.10.6 Treatment

Click on the Treatment tab. The screen below will appear. This tab contains unit cost information for adult and child ART, including drug, lab, prophylaxis, nutrition supplements and service delivery costs (see the RNM input editors section for descriptions of the interventions, and the Methodology section for a complete description of the equations used).

1. Click on the cell for the unit cost for each intervention and enter a value. If you have used default values and you want to change them, click on the cell that you want to change and enter the new value. If you are providing different regimens for first-line or second-line ART, enter a weighted average of the costs.

2. Since ARV drug costs change quickly, you must enter unit costs for all of the projection years. Recall that you may use special editing functions (Duplicate, Interpolate, etc.) to fill in values by right-clicking on the cell and selecting from the dropdown menu that appears.

3. You may change the currency by selecting a different one from the dropdown menu labeled "Currency".

4. Click on "OK" to save all of the entries in the Unit Cost tab. Clicking on "Cancel" will cancel all of the entries.

RNM - Unit costs - RNM test	2008	2009	2010	2011	2012	2013	2014	2015
Adults (costs per patient per year)								
First line ART drugs	143.0	150.1	157.3	164.4	171.6	178.7	185.9	193.0
Second line ART drugs	819.0	819.0	819.0	819.0	819.0	819.0	819.0	819.0
Additional ART drug costs for TB patients (male)	240.8	240.8	240.8	240.8	240.8	240.8	240.8	240.8
Additional ART drug costs for TB patients (Female)	240.8	240.8	240.8	240.8	240.8	240.8	240.8	240.8
Lab costs for ART treatment	190.0	190.0	190.0	190.0	190.0	190.0	190.0	190.0
Drug and lab costs for opportunistic infections	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cotrimoxazole prophylaxis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TB prophylaxis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nutrition supplements in first six months	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Children (costs per patient per year)								
ARV drugs	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lab costs for ART treatment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Service delivery costs								
Cost per in-patient day	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cost per out-patient visit	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Service delivery requirements (per patient per year)								
ART: in-patient days	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ART: out-patient visit	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
OI treatment: in-patient days	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
OI treatment: out-patient days	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Tabs: General population | Most at-risk populations | Medical services | Male circumcision | PMTCT | Treatment

Ok | Cancel | Source | Currency USD

7.6.6.11 Program support

Click on "Program support" from the module menu bar. The following screen will appear (see the RNM input editors section for descriptions of the interventions, and the Methodology section for a complete description of the equations used):

1. Click on the arrow (circled above) to select either a number or percent value for each support function. No default values are available here, so click on each cell for which you would like to enter data and type in the value. The value is automatically copied into all of the projection years.

2. If you want to see or enter values for the other years of the projection, click on the "Expand" button. Click on any cell to change its value. Click on "Collapse" to return to the original display of only the first year. Recall that you may use special editing functions (Duplicate, Interpolate, etc.) to fill in values by right-clicking on the cell and selecting from the dropdown menu that appears.

3. To add a support function, click on the "Add" button (circled below), and fill in the screen that will appear:
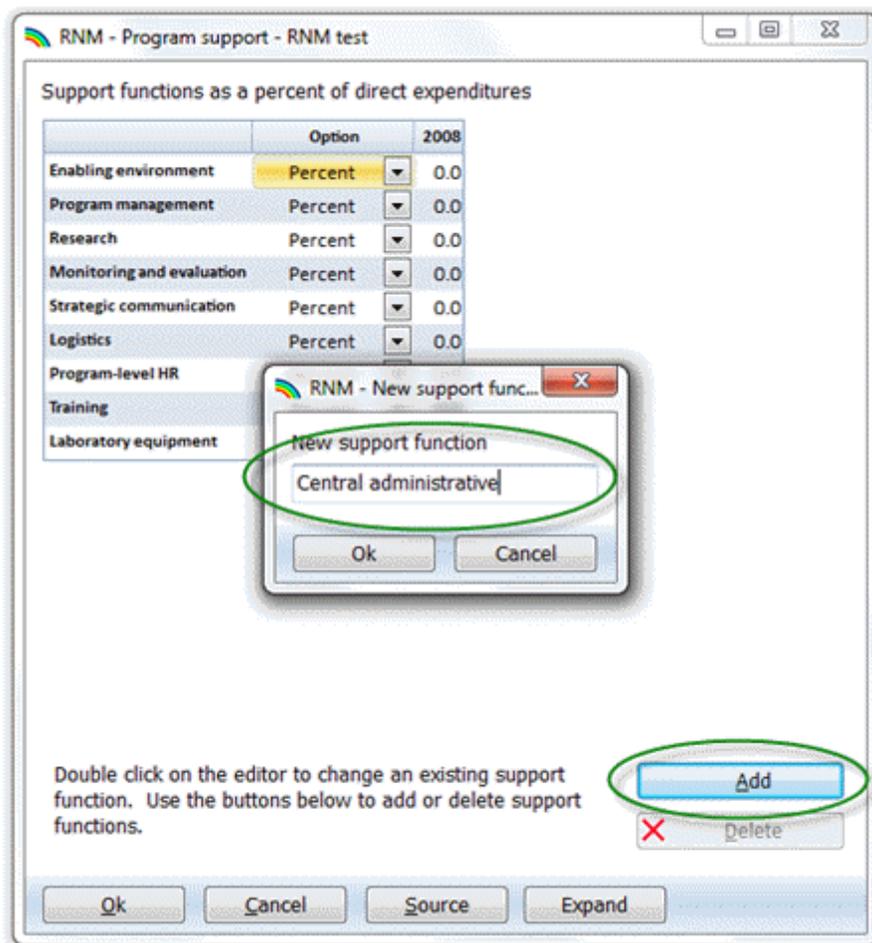
4. Click on the dropdown arrow to select either number or percent as the value for the additional support function, which appears in blue font. Click on the data cell to enter a value. If you enter the value when only the first year of the projection is displayed, the value is automatically copied into all of the projection years (see below).

5. If you want to delete one of the added support functions, click on the function you want to delete, and then click on the "Delete" button.

6. Click on the arrow (circled above) to select either a number or percent value for each support function. No default values are available here, so click on each cell that requires data and enter a value. The value is automatically copied into all of the projection years.

7. Click on "OK" to save all of the entries in the Unit Cost tab. Clicking on "Cancel" will cancel all of the entries.

7.6.6.12 Mitigation

Click on "Mitigation" from the module menu bar (see the RNM input editors section for descriptions of the interventions, and the Methodology section for a complete description of the equations used). The following screen will appear:
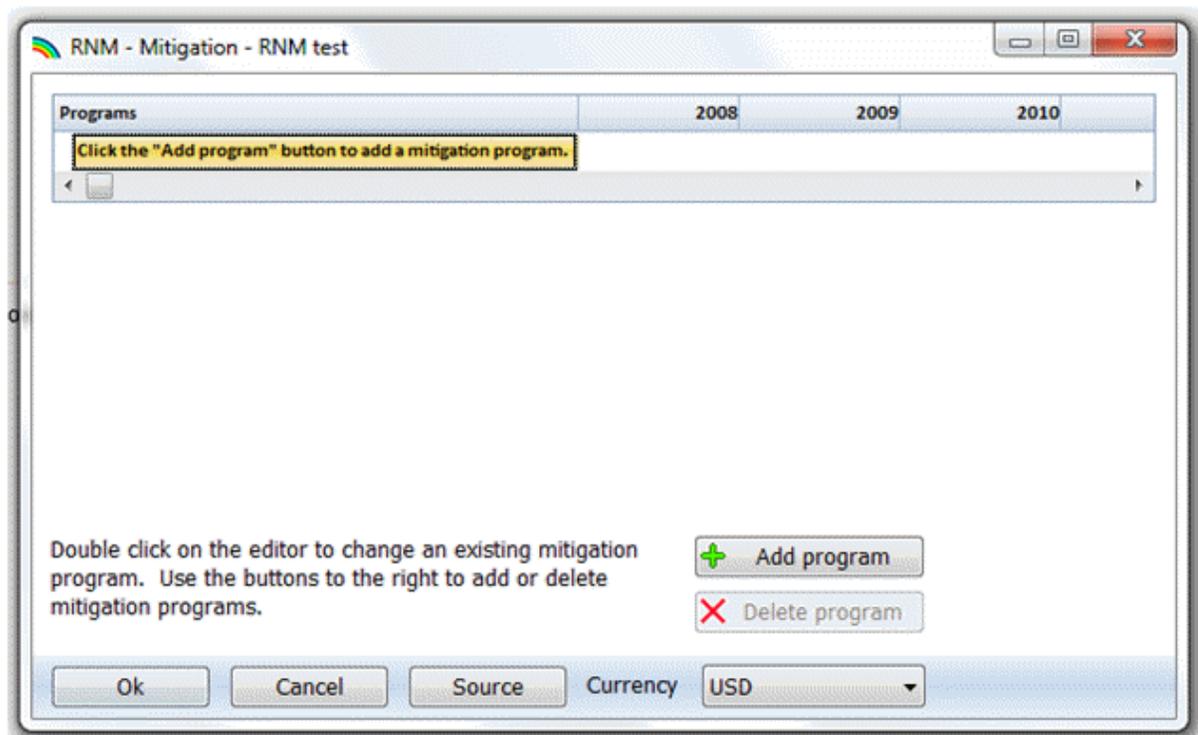
1. As discussed in the RNM input editors section, there are no pre-set programs for mitigation. Each program must be added, and total resources required for each year must be supplied for each program.

2. To add a mitigation program, click on the "Add program" button (circled below). Type in the name of the program in the box highlighted in yellow (also circled below).

3. Enter the total resources required for the program for each year by clicking on the cell and typing in the value. Recall that you may use special editing functions (Duplicate, Interpolate, etc.) to fill in values by right-clicking on the cell and selecting from the dropdown menu that appears.
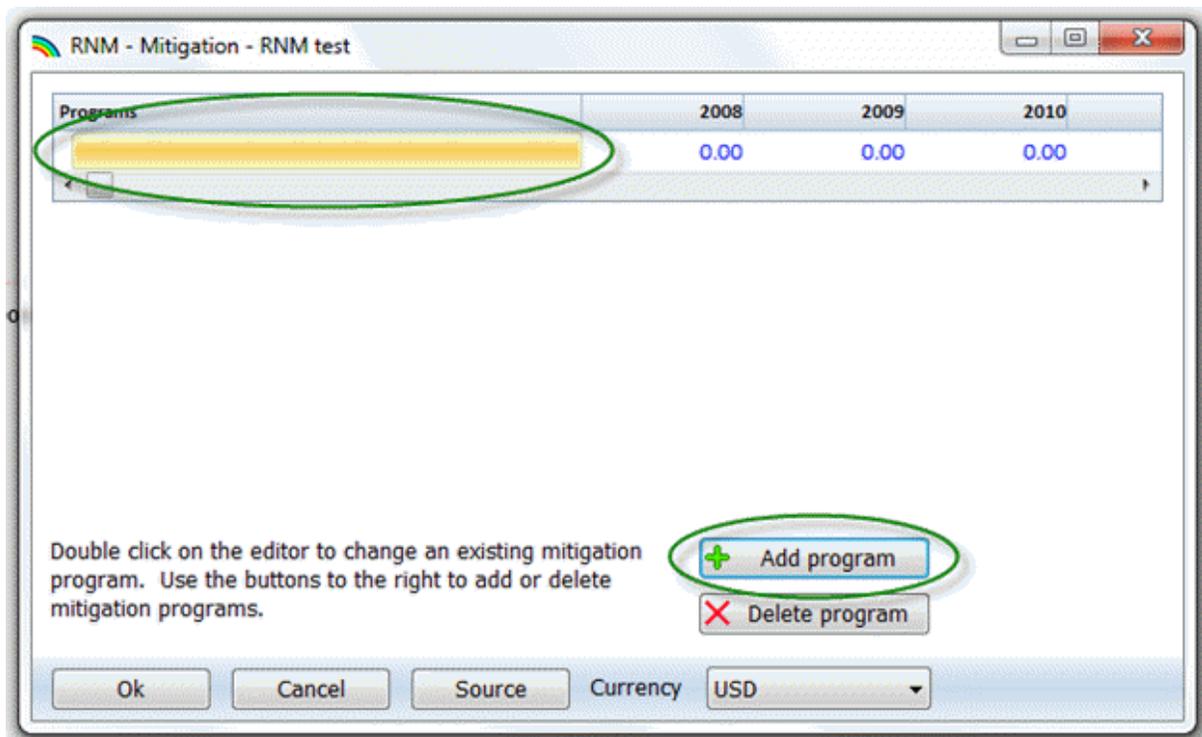
4. If you want to delete one of the mitigation programs, click on the function you want to delete, and then click on the "Delete" button.

5. Click on "OK" to save all of the entries in the Unit Cost tab. Clicking on "Cancel" will cancel all of the entries.

7.6.6.13 Saving the input data

Once you have entered the projection inputs, it is a good idea to save the data onto your hard disk. To save the projection, either choose "Save projection" from the application button or select "Save" from the set of file commands displayed when "Home" is selected on the menu bar. The data will be saved using the file name you specified earlier.

7.6.6.14 Results

7.6.6.14.1 Making the projection

Whenever you enter data for a new projection or edit the variables, Spectrum will note that the data have been changed. The next time you try to display an indicator, it will inform you that the data may have changed and ask if you want to recalculate the projection. Normally, you should answer "Yes" to this question. Spectrum will then make the projection. This step may take only a few seconds or much longer, depending on the length of the projection and the number of modules being used. Once the projection is made, you will not be asked if you want to project the population again, unless you edit the variables.

7.6.6.14.2 Examining the output

To see the results of the projection, select "Results" from the module menu bar. From the pull-down menu you will see a menu showing the categories of indicators available:

- Resources required

- Number of people reached

- Adult treatment costs

- Child PMTCT and treatment costs

Choose one of these categories and you will see one final menu listing the indicators available in that category. Select one of the indicators. Then you will see the display dialogue box. It will look similar to the one shown below.
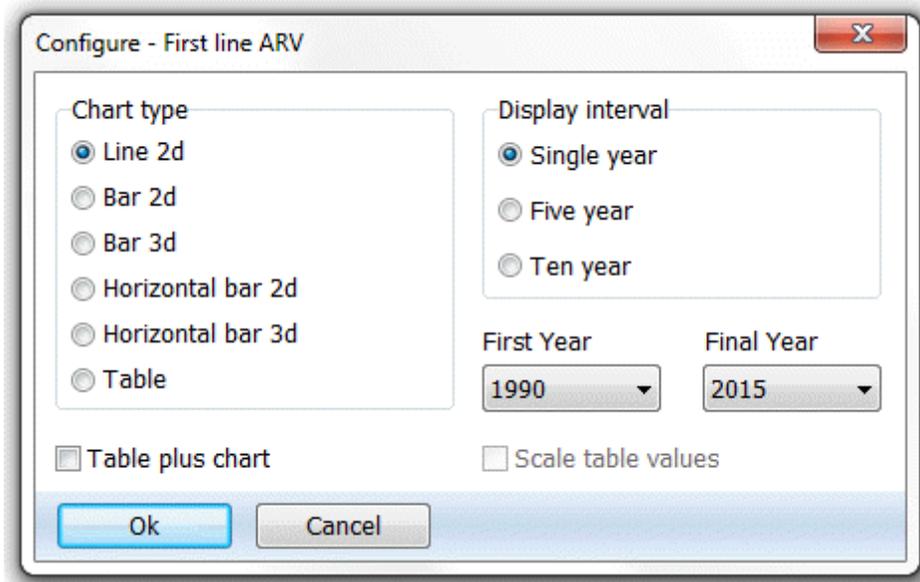
The exact choices available will depend on the indicator you have selected. Different chart types are available, as well as a Table display (or both). If you want to copy and paste the results into another program for further analysis, choose the "Table" display.

The display will normally be in single years, but you can change it to display every five or 10 years if desired. The chart type is also set through this dialogue box. Click on the button next to the type of display you want. Normally the display will show all the years in the projection. However, if you want to see only part of the projection, you can change the final year by selecting a new final display year from the "Final year" list box.

Once you are satisfied with the type of display, click the "OK" button and the display will appear. It will look similar to the display shown below.
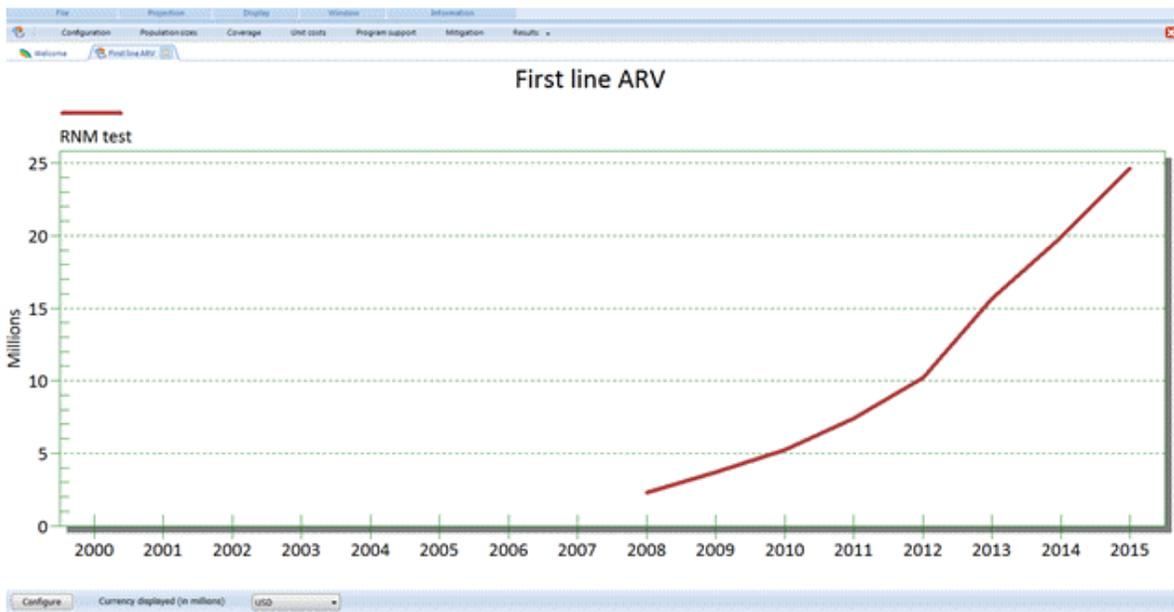
All the projections that are currently in use will be displayed on the same graph.

You can change the configuration of the display by clicking the "Configure" button. You can also change the type of display by placing the mouse pointer anywhere inside the chart and clicking with the right mouse button. You can also display the results in a different currency by clicking on the dropdown menu next to "Currency displayed".

To close the display, click on the "Close" button. You do not have to close the display immediately. You can choose to display another indicator and it will appear on top of the first display. The first display will be covered, but it will still be there. You can return to any previous display that you have not closed by clicking on its tab at the top of the screen.

7.6.6.14.3 Graphs and bar charts

Spectrum will display a variety of graphs and bar charts, including:

- Line charts

- Two- and three-dimensional bar charts (column charts)

- Two- and three-dimensional horizontal bar charts

- Two- and three-dimensional overlap bar charts (bars for multiple projections are shown on top of one

    another)

- Three-dimensional perspective bar charts

To use in another program, you can use the "Copy" command in Spectrum and then "Paste" into another program.

7.6.6.14.4 Tables

Spectrum will also display data in the form of tables. In tables, each projection that is in use will be displayed in a separate column. You can scroll through the table to see all the years by using the PgUp and PgDn keys or by using the mouse.

You can also copy and paste the results here for use in another software program.

7.6.6.14.5 Summary tables

The final choice in each section is a summary table showing all the indicators and input assumptions. You can scroll through this page to see all the output. If you have more than one projection loaded, the indicators for the second projection will immediately follow the first.

7.6.7   Methodology

Recall that the basic equation used in the RNM calculates total resources required for each intervention at any time t as the product of target population, coverage rate and unit cost:

(1) Resources required$_t$ = Target population$_t$ x coverage$_t$ x unit cost$_t$

The details of the calculations for each of the outputs that can be displayed in the RNM are presented in this chapter.

7.6.7.1   Prevention

Priority populations

Youth focused interventions: Resources required = ((Male population aged 6-12 x Male primary gross enrollment rate + Female population aged 6-12 x Female primary gross enrollment rate) / (Primary student teacher ratio x % primary students with teachers trained in AIDS / Frequency of teacher re-training (years) x Cost per teacher trained in primary school education)) + ((Male population aged 13-18 x Male secondary gross enrollment rate + Female population aged 13-18 x Female secondary gross enrollment rate) / (Secondary student teacher ratio x % secondary students with teachers trained in AIDS / Frequency of teacher re-training (years) x Cost per teacher trained in secondary school education)) + (Male population 13-18 + Female population 13-18) x % out-of-school youth reached x Cost of peer education for out of school youth

Female sex workers and their clients: Resources required = Female sex workers in base year x pop 15-49 in year t / pop 15-49 in base year x coverage (% female sex workers reached by intervention per year) x unit cost (cost per female sex worker targeted)

Male sex workers and their clients: Resources required = Male sex workers in base year x pop 15-49 in year t / pop 15-49 in base year x coverage (% male sex workers reached by intervention per year) x unit cost (cost per male sex worker targeted)

Workplace: Resources required = (Formal sector employees eligible for workplace programs) x (% workforce receiving peer education/100 x cost per person in employment reached (peer education) + % workforce receiving STI treatment x cost per STI treated in workplace)

Injecting drug users: Resources required for the five separate programs are:

IDU harm reduction: Number of IDU x pop 15-49 in year t / pop 15-49 in base year x % of IDUs receiving harm reduction intervention/100 x cost of harm reduction programs per person contacted

IDU testing and counseling: Number of IDU x pop 15-49 in year t / pop 15-49 in base year x % of IDUs receiving Counseling and Testing/100 x Cost of Counseling and Testing per IDU targeted

IDU community outreach and peer education: Number of IDU x pop 15-49 in year t / pop 15-49 in base year x % of IDUs receiving Community Outreach and Peer Education/100 x Cost of Community Outreach and Peer Education per IDU targeted

IDU needle and syringe exchange: Number of IDU x pop 15-49 in year t / pop 15-49 in base year x % of IDUs receiving Needle and Syringe Exchange/100 x Cost per needle distributed and destroyed x Number of injections per year

IDU drug substitution: Number of IDU x pop 15-49 in year t / pop 15-49 in base year x % of IDUs receiving Drug Substitution/100 x Cost of Drug Substitution per IDU targeted x Percent IDU opioid dependent

Men who have sex with men: Resources required = MSM in base year x pop 15-49 in year t / pop 15-49 in base year x coverage (% MSM reached by intervention per year) x unit cost (cost per MSM targeted)

Community mobilization: Resources required = Adult population 15-49 x coverage (% reached by intervention per year) x unit cost (cost per person reached)

Service delivery

Condom provision: Resources required = Male pop 15-49 x 15-49 sexually active x 15-49 males reporting non-regular partners x (Number of sex acts with regular partners per year x % of marrieds with casual partners using condoms in marital sex/100 + Number of sex acts for casual non-regular partners per year x % of casual sex acts covered with condoms/100) x Cost per male condom distributed by the public sector x (1 + Condom wastage during storage and distribution)

STI management: Resources required = (Number of new cases of treatable STIs - male (incidence) x Percent of STIs that are symptomatic - males x % males with STI receiving treatment + Number of new cases of treatable STIs - female (incidence) x Percent of STIs that are symptomatic - females x % females with STI receiving treatment) x Cost per STI treated in clinics

Voluntary counseling and testing: Resources required = (Male pop 15-49 + female pop 15-49) x % of adult population receiving VCT each year x cost per VCT client

Male circumcision: Resources required = Male pop 15-49 x % of adult males currently circumcised x % males 15-49 circumcised x cost per circumcision

PMTCT: Resources required = Pre-test counseling costs + HIV positive women counseling costs + Testing costs for all HIV positive women + PRC testing for newborns and testing after cessation of breast feeding + service delivery costs + Cost of formula + Cost of Single dose nevirapine + cost of dual ARV + Cost of Option A + Cost of Option B + cost of Triple ART before pregnancy + cost of triple ART during pregnancy + Cost of Option A with breastfeeding + cost of Option B with breastfeeding where:

Pre-test counseling costs = Pre-test counseling cost x number of births x (number women on PMTCT / number need PMTCT)

HIV positive women counseling costs = Post-test cost x number women on PMTCT

Testing costs for all HIV positive women = PMTCT cost for mother x number of births x (number women on PMTCT/number need PMTCT)

PCR testing for newborns and testing after cessation of breast feeding = (Cost of PCR for infants after birth + Cost for testing of infants after breast feeding) x Number women on PMTCT

Service delivery costs = Cost of service delivery x number of women on PMTCT

Cost of formula = cost of formula x number of women on PMTCT

Cost of single dose nevirapine = (1 + 3 x 2 x 5 / 50) x Cost of Nevirapine 200 x Number need PMTCT x Percent treated with single dose nevirapine

{Single dose for baby of 3kg baby, dose of 2mg/kg, 50mg NVP from 5ml bottle, plus single dose for mother}

Cost of dual ARV = (Cost of AZT + Cost of Three TC) x 12 x 7 x Number need PMTCT x Percent treated with Dual ARV

{12 weeks, 7 days/wk}

Cost of Option A = Cost AZT x (40-14) x 7 x Need for PMTCT x Percent treated with Option A

{26 weeks, 7 days/wk}

Cost of Option B = Cost of Triple Prophylaxis x 26 x 7 x Need for PMTCT x Percent treated with Option B

{26 weeks, 7 days/wk}

Cost of Triple ART before pregnancy = (Cost of Triple treatment x (26+52) x 7 + Cost of Nevirapine for infants x 6 x 7) x Need for PMTCT x Percent treated with Triple ART before pregnancy

{26 weeks pre-partum, 52 weeks post-partum for mom, 6 weeks for infant}

Cost of Triple ART during pregnancy = (Cost of Triple treatment x (26+52) x 7 + Cost of Nevirapine for infants x 6 x 7) x Need for PMTCT x Percent treated with Triple ART during pregnancy

{26 weeks pre-partum, 52 weeks post-partum for mom, 6 weeks for infant}

Cost of Option A with breastfeeding = Cost of Nevirapine for infants x (52 x 7 + 7) x Need for PMTCT - Percent treated with Triple ART before pregnancy - Percent treated with Triple ART during pregnancy x Percent treated with Option A with breastfeeding

{Mother = 12 months BF}

Cost of Option B with breastfeeding = Cost of triple prophylaxis x 365 x (Need for PMTCT x (1- Percent treated with Triple ART before pregnancy - Percent treated with Triple ART during pregnancy)) x Percent treated with Option B with breastfeeding

{Mother = 12 months BF}

Mass media: Resources required = Adult population 15-49 x coverage (% reached by intervention per year) x unit cost (cost per person reached)

Health care

Blood safety: Resources required = Total population / 1000 x Blood units required per 1,000 people x % of units of blood for transfusion tested/100 x Cost per blood unit tested

Post-exposure prophylaxis: Resources required = Total population / 1000000 x PEP kits required per million population x Cost per PEP kit

Safe injection: Resources required = (Pop <2 x Average number of immunizations per child 0-23 months + Total population x Number of adult injections per person per year x (1 - Percent reduction in number of other injections)) x Percent of injections that are unsafe x Percent of unsafe injections replaced with AD syringes x Additional cost for AD syringes

Universal precautions: Resources required = Hospital beds per 1000 population x Percent of hospital beds covered/100 x Annual cost per hospital bed

7.6.7.2   Care and treatment services

Adult ARV therapy

ARV therapy cost: Resources required = First-line ART cost + Second-line ART cost + TB/ART cost + Lab test cost + Cotrim prophylaxis cost + TB prophylaxis cost + Nutrition cost + First-line service delivery cost + Second-line service delivery cost where:

> **First-line ART cost =** Cost of first-line ART drugs per person per year * Number 15+ receiving ART

> **Second-line ART cost =** Cost of second-line ART drugs per person per year * Number 15+ receiving second-line ART

> **TB/ART cost =** Number 15+ newly receiving ART * ((Additional ART drug costs for TB males + Additional ART drug costs for TB females)/2) * (Number of TB cases/15+ total need for ART)

> **Lab test cost =** ART lab costs * (number 15+ receiving ART + Number 15+ receiving second-line)

> **Cotrim prophylaxis cost =** Cost of Cotrim prophylaxis per person per year * (15+ total need for ART – (Number 15+ receiving ART + Number 15+ receiving second-line))

> **TB prophylaxis cost =** Cost of TB prophylaxis per person per year * (15+ total need for ART – (Number 15+ receiving ART + Number 15+ receiving second-line))

> **Nutrition cost =** Cost of nutrition supplement for sVI months * (number 15+ newly receiving ART + number 15+ newly receiving second-line)

> **First-line service delivery cost =** Number 15+ receiving ART * (Cost per inpatient day * Number ART inpatient days + Cost per outpatient day * Number of ART outpatient days)

> **Second-line service delivery cost =** Number 15+ receiving second-line * (Cost per inpatient day * Number ART inpatient days + Cost per outpatient day * Number of ART outpatient days)

Non-ARV care and prophylaxis

Non-ART care and prophylaxis: Resources required = (Number 15+ AIDS deaths + Number 15+ newly needing ART * (1-0.5 * (Number 15+ receiving ART + Number 15+ receiving second-line) / 15+ total need for ART)) * (Cost per inpatient day * OI treatment inpatient days + Cost per outpatient day * OI treatment outpatient days)

Child ARV therapy

Child treatment costs = (Cost of ARV drugs for children + Lab cost for children + Cost per inpatient day * Number of ART inpatient days + Cost per outpatient day * Number of ART outpatient days) * Number of children on ART

7.6.7.3   Program support

Resources required for:

Enabling environment	= Amount	% for Enabling environment x sum of all resources required
Program management	= Amount	% for Program management x sum of all resources required
Research	= Amount	% for Research x sum of all resources required
Monitoring and evaluation	= Amount required	% for Monitoring and evaluation x sum of all resources
Strategic communication	= Amount	% for Strategic communication x sum of all resources required
Logistics	= Amount	% for Logistics x sum of all resources required
Program-level HR	= Amount	% for Program-level HR x sum of all resources required
Training	= Amount	% for Training x sum of all resources required
Laboratory equipment	= Amount	% for Laboratory equipment x sum of all resources required

7.6.7.4   Mitigation

Resources required for mitigation interventions are simply the amounts that are entered into the RNM.

7.6.8   Glossary of terms

Most of the definitions were obtained from the United Nations web site: http://www.unaids.org/

Adult. An adult is defined as a person aged 15 or older.

AIDS. The abbreviation for the acquired immune deficiency syndrome, a disabling and fatal disease caused by the human immunodeficiency virus (HIV).

HIV. The human immunodeficiency virus is the virus that causes AIDS. Two types of HIV are currently known: HIV-1 and HIV-2. Worldwide, the predominant virus is HIV-1. Both types of virus are transmitted by sexual contact, through blood, and from mother to child, and they appear to cause

clinically indistinguishable AIDS. However, HIV-2 is less easily transmitted, and the period between initial infection and illness is longer in the case of HIV-2.

HIV Infection. Infection with the human immunodeficiency virus (HIV). HIV infection is primarily a sexually transmitted infection, passed on through unprotected penetrative sex. The virus can also be transmitted through blood transfusions, through the use of unsterilized injection equipment or cutting instruments, and from an infected woman to her fetus or nursing infant.

Interpolation. Given two numbers that serve as boundary points, it is possible to estimate the values that lie at intervals between the two points. For example, if the HIV prevalence rate for a country or region was actually measured only in 1985 and in 1995, by assuming even increments from year to year, it is possible to interpolate a TFR for each intervening year. Spectrum uses a linear form of interpolation so that the difference between each annual value is the same. Other nonlinear forms of interpolation are also possible but are not used in Spectrum.

Life Expectancy. The average number of years a newborn can expect to live, based on the mortality and conditions of the time.

Model. Computer system designed to demonstrate the probable effect of two or more variables that might be brought to bear on an outcome. Such models can reduce the effort required to manipulate these factors and present the results in an accessible format.

Module. Synonym for "model."

Orphan. In this manual, an orphan is defined as a child under the age of 18 whose mother or father, or both, has died of AIDS.

Perinatal and Perinatal Transmission. Pertaining to or occurring during the periods before, during, or shortly after the time of birth; that is, before delivery from the 28th week of gestation through to the first seven days after delivery. The transmission of HIV from an infected woman to her fetus or newborn child is referred to as perinatal transmission.

Prevalence. The proportion of a defined population with the infection, disease, or other health-related event of interest at a given point or period of time.

Seroprevalence (HIV, STD). The percentage of a population from whom blood has been collected that is found, on the basis of serology, to be positive for HIV or other STD agents at any given time.

7.6.9 Acronyms and abbreviations

3TC   Epivir, also known as lamivudine

AD   auto-destruct

AIDS   acquired immune deficiency syndrome

AIM   AIDS Impact Model

ART   antiretroviral treatment

ARV   antiretroviral

AZT	Azidodeoxythymidine, also known as zidovudine
DHS	Demographic and Health Survey
EIMC	Early infant male circumcision
FSW	female sex worker
GDP	gross domestic product
GNP	gross national product
HIV	human immunodeficiency virus
HR	human resources
IDU	injecting drug user
IEC	information, education and communication
ILO	International Labour Organization
M&E	Monitoring and evaluation
MC	Male circumcision
MOH	Ministry of Health
MSM	men who have sex with men
MSW	male sex worker
NACP	national AIDS control program
NNRTI	Non-nucleoside reverse transcriptase inhibitor
NRTI	Nucleoside reverse transcriptase inhibitor
OI	opportunistic infection
PCR	polymerase chain reaction
PEP	post-exposure prophylaxis
PEPFAR	President's Emergency Plan for AIDS Relief
PI	protease inhibitor
PMTCT	prevention of mother-to-child transmission
RNM	Resource Needs Module

STI	sexually transmitted infection
TB	tuberculosis
UNAIDS	Joint United Nations Programme on HIV/AIDS
UNGASS	United Nations General Assembly Special Session on HIV/AIDS
UNICEF	United Nations Children's Fund
USAID	United States Agency for International Development
VCT	voluntary counseling and testing
WHO	World Health Organization
WHO-CHOICE	World Health Organization CHOosing Interventions that are Cost-Effective

7.7 TIME
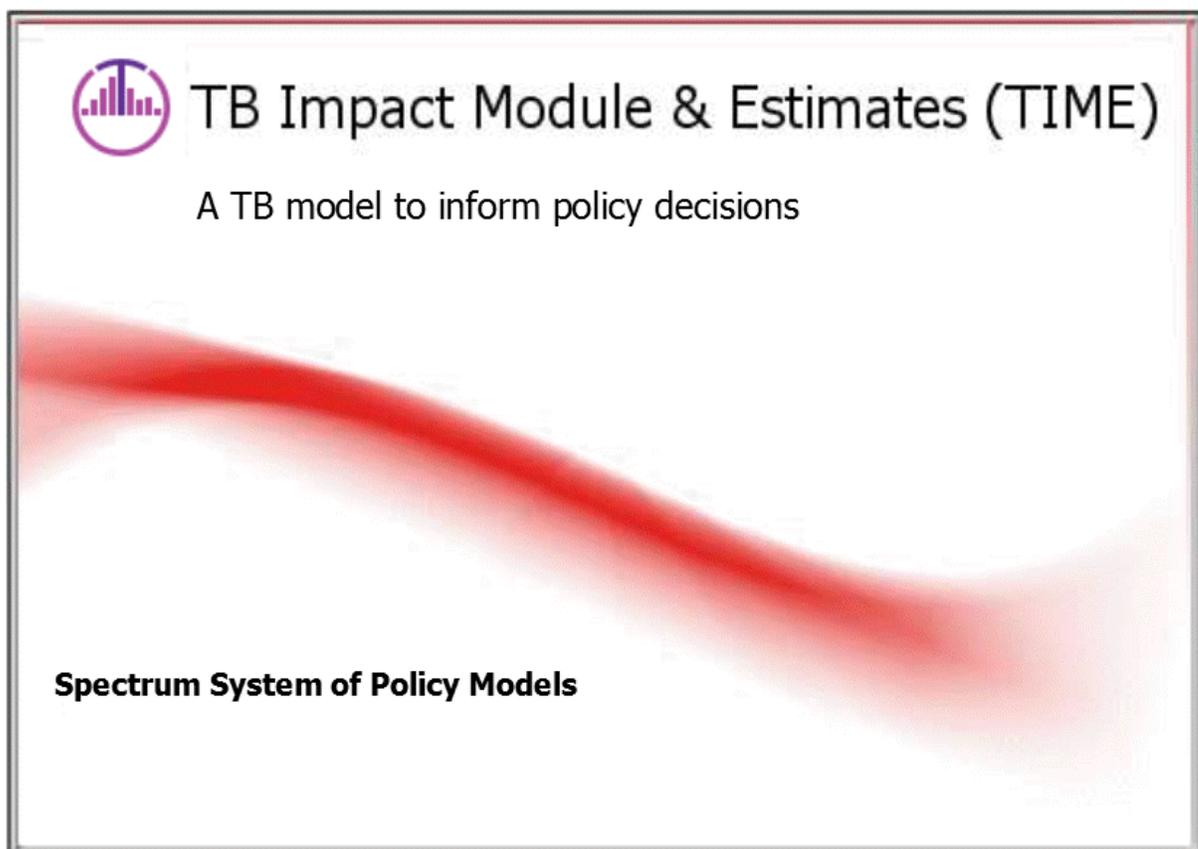
TIME comprises two models:

- **TIME Estimates:** This module is used for producing estimated and projected values for key TB indicators. These TB indicators include: TB incidence (particularly its split by HIV status), TB mortality (estimated from case fatality ratios with respect to TB incidence), TB notification and its breakdown by case type (new or retreatment) and MDR among notified new and retreatment TB cases. The module is used to calculate TB/HIV incidence and mortality using UNAIDS estimates on HIV prevalence, CD4 distribution and ART coverage.

  These estimates are used as population input for cost calculations in TB One Health Costing. It is also used to provide indicator trends to which the TIME Impact model is fit. All indicators are produced by cubic-spline regression techniques.

- **TIME Impact**: The TIME Impact module allows users to generate short and long term projections of TB incidence and notification for their population of interest, and assess the epidemiological impact of a variety of user-defined interventions. Results are stratified by treatment history, smear and MDR status, based on data from the WHO Global TB Database. Results are used to generate cost-effectiveness estimates of key TB interventions using the One Health TB Costing tool.

  It uses a dynamical compartmental TB model, which is linked to the demography (DemProj) and the HIV and modules of Spectrum, from which it draws population and HIV data respectively. TIME Impact models are first calibrated to baseline country-level epidemics (with information supplied by the TIME Estimates model) and are then used to study the impact of TB interventions on TB incidence, prevalence, mortality and notification. The costs of these interventions are calculated with TB Costing module within One Health.

- **TIME Estimates and TIME Impact** interact much like AIM and Goals do for HIV modeling: TIME Estimates are used to prepare official estimates (particularly for HIV+ TB incidence and mortality) and TIME Impact is used to study the impact of TB interventions on TB incidence, notification, mortality and MDR outcomes.

7.7.1 TIME Estimates

7.7.1.1 What is TIME Estimates?

This section outlines the Spectrum TIME Estimates module for the estimation of key TB indicators at country level, with an emphasis on indicators relevant to HIV-TB, and with the aim of estimating the potential impact of HIV interventions (e.g. ART) on the burden of HIV-TB [1]. The model can also be used to study the impact of increased TB notification on the TB-related mortality.

An immediate application of the TIME Estimates module is to estimate the number of incident TB cases by CD4 category (these data are produced by the Spectrum HIV model [2]). Many countries follow 2010 ART guidelines regarding TB cases, which recommend that HIV+ cases with active TB must initiate treatment regardless of CD4 count. Many of them want to expand ART eligibility to higher CD4 thresholds for the general population also. The model can be used to estimate resource requirements above those that will result from current ART guidelines. Another important use is to estimate HIV+ TB mortality and the impact of ART expansion.

The model is essentially an incidence model, which is fit to incidence data from the WHO GTB database and disaggregated according to CD4 category. To this end, a regression method is devised to estimate relative risk (RR) for TB incidence according to the CD4 categories used by Spectrum for national HIV projections. Spectrum data are based on the national projections prepared towards the UNAIDS Report on the Global AIDS Epidemic 2012.

TB mortality is calculated as product of incidence and case fatality ratios, and the model can easily be used to study the impact of increased notification on TB-related mortality.

7.7.1.2   TIME Estimates input editors

7.7.1.2.1 Program statistics

This section of the module organizes country TB program statistics as reported to the WHO. The editor is arranged into several tabbed sub-sections, as depicted below:

- **TB Incidence** (all forms, HIV- and HIV+), as well as upper and lower bounds for the estimates.

- **TB Notification**, focusing on the case types required of the costing of the TB program by the TB costing module of One Health. The upper part of the table displays total notification (all types). The lower part specifies the breakdown of notification by different types: New and Relapse (by Pulmonary, bacteriologically confirmed or clinically diagnosed and also extra-pulmonary), Re-treatment as the percentage of cases that are below the age of 15. The user can specify either an absolute value or a percentage of total notifications in the base year (last year of data available in the WHO TB database) and the base year ratio of total notification is projected forward to provide a short-term estimate of each notified case type.

- **HIV+ TB Burden**, showing the results of different types of HIV-TB surveillance efforts, namely surveys, routine testing of TB cases and testing through sentinel surveillance. Also showing information related to HIV+ TB cases receiving ART. This information is used to estimate HIV+ TB incidence.

- **MDR Burden**, displaying MDR burden in absolute numbers and as a percent of new pulmonary and retreated cases, as well as upper and lower bounds for the estimates. Also allows XDR-TB to be specified as a percentage of total MDR-TB.

- **MDR Case Detection**, showing the percentage of cases that receive drug sensitivity tests.

The data displayed in the Program Statistics editor is read from the WHO TB database. Any changes to these data must be communicated with the WHO Global TB Program. The Program Statistics editors are displayed below.

Figure 1: TIME TB Program Statistics: TB Incidence

| TB Incidence | TB Notification | HIV+ TB Burden | MDR Burden | MDR Case Detection |

Number of incident TB cases

Kenya	1990	1991	1992	1993	1994	1995	1996
1. Total TB cases (sum of HIV- and HIV+)							
Estimate	32,890	34,036	35,521	37,716	40,995	45,729	52,163
High bound	35,118	35,651	36,938	38,956	42,307	47,191	53,684
Low bound	30,734	32,458	34,131	36,495	39,703	44,289	50,663
Total TB cases HIV-							
Estimate	17,890	17,036	15,521	15,716	15,995	16,729	19,163
High bound	19,118	16,651	14,938	13,956	14,307	15,191	16,684
Low bound	17,734	17,458	16,131	16,495	16,703	18,289	20,663
Total TB cases HIV+							
Estimate	15,000	17,000	20,000	22,000	25,000	29,000	33,000
High bound	16,000	19,000	22,000	25,000	28,000	32,000	37,000
Low bound	13,000	15,000	18,000	20,000	23,000	26,000	30,000
Total TB cases HIV+ ART							
Estimate	0	0	0	0	0	0	0

- **Projected:** indicates an estimate of TB incidence based on on fiiting a curve to historical TB incidence. This projection is used for years beyond the last year for which official estimates exist.
- **Estimate** are the historical estimates of TB incidence.
- **High:** is an upper bound on an estimate.
- **Low:** is a lower bound on an estimate.

Figure 2: TIME TB Program Statistics: TB Notification by treatment history and for new cases a case type breakdown

| TB Incidence | TB Notification | HIV+ TB Burden | MDR Burden | MDR Case Detection |

Kenya	1990	1991	1992	1993	1994
Total cases notified (new, retreatment and other)	11,788	12,320	14,599	20,451	22,930
MDR Notification					
among new cases					
among retreatment cases					
Total MDR cases notified	0	0	0	0	0

| Number of cases | Percentage of notified |

☐ Enable editing of absolute numbers
☐ Enable editing of percentages

	2014	2015	2016	2017	2018
Total cases notified (new, retreatment and other)					
Projected	87,928	82,620	77,434	72,365	67,405
Estimate	89,294	0	0	0	0
New					
Pulmonary, bacteriologically confirmed	34,997	34,997	34,997	34,997	34,997
Pulmonary, clinically diagnosed	30,872	30,872	30,872	30,872	30,872
Extrapulmonary	14,640	14,640	14,640	14,640	14,640
Relapse					
Pulmonary, bacteriologically confirmed	3,569	3,569	3,569	3,569	3,569
Pulmonary, clinically diagnosed	2,947	2,947	2,947	2,947	2,947
Extrapulmonary	1,000	1,000	1,000	1,000	1,000

Figure 3: TIME TB Program Statistics: HIV+ TB Burden, surveillance data, TB-ART information

HIV+	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Surveys										
Prevalence of HIV-TB				45.00	44.00	41.00				
High bound				48.00	46.00	45.00				
Low bound				42.00	42.00	37.00				
Sentinel HIV										
Prevalence of HIV-TB										
High bound										
Low bound										
Routine Testing										
Prevalence of HIV-TB	52.00	48.00	45.00	44.00	41.00	39.00	38.00	37.00	36.00	
High bound	52.00	48.00	45.00	44.00	41.00	39.00	38.00	38.00	36.00	
Low bound	52.00	48.00	45.00	44.00	41.00	39.00	38.00	37.00	35.00	
Coverage of HIV testing	60.00	79.00	83.00	88.00	91.00	93.00	95.00	94.00	94.00	

Percentage of HIV+ TB cases receiving ART

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Percentage of HIV+ TB cases receiving ART	0.00	3.35	8.06	17.69	23.88	30.64	40.78	46.73	54.25	58.22	55.90
Percentage of ART patients receiving ART for more than one year	0.00	6.47	37.77	46.77	61.61	70.77	72.46	76.05	79.10	84.11	90.91

☑ Use AIM to set the percentage of TB cases receiving ART for more than one year

Figure 4: TIME TB Program Statistics: MDR burden among notified new and re-treatment cases. Percent of the MDR cases which are MDR also stated.

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2

Number of notified MDR cases

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2
MDR among new pulmonary cases	Source: Model											
Estimate	1,400											
High bound	2,700											
Low bound	200											
Percent(%)	2.20											
High bound	4.10											
Low bound	0.30											
MDR among re-treated cases	Source: Surveillance											
Estimate	1,100											
High bound	1,200											
Low bound	930											
Percent(%)	14.00											
High bound	15.00											
Low bound	12.00											
XDR among MDR (%)	0	0	0	0	0	0	0	0	0	0	0	

Figure 5: TIME TB Program Statistics: MDR Case Detection, i.e. the percentage of notified new and re-treatment cases who receive a drug susceptibility test.

Tabs: TB Incidence | TB Notification | HIV+ TB Burden | MDR Burden | MDR Case Detection

Drug sensitivity tests (DST)

Drug sensitivity tests (DST)	1970	1971	1972	1973	1974	1975
Proportion of cases tested for MDR						
HIV- cases						
Among new cases (all forms)	0.0	0.1	0.1	0.1	0.2	0.2
Among re-treated cases (all types)	0.0	0.2	0.2	0.2	0.3	0.3
HIV+ cases						
Among new cases (all forms)	0.0	0.1	0.1	0.1	0.2	0.2
Among re-treated cases (all types)	0.0	0.2	0.2	0.2	0.3	0.3

7.7.1.2.2 Fitting and displaying TB indicators

TIME Estimates provides an interface for fitting and displaying indicators. Default projections for all indicators and most countries (around 150 countries) are read from a database into which pre-fitted

projections are loaded. While the default projections generally fit available data well, there are projections for some countries which demand data adjustments and re-fitting.

TIME Estimates uses a generic interface for curve fitting. The top-left panel provides a way of selecting a given indicator. Once selected, the user can set a number of parameters that will influence the fitting of the curve to underlying data, based on cubic spline fitting.

General fitting parameters

The general parameters which are available for each indicator, are:

- **The projection interval**: which is set in the **Configuration** tab. The setting is called "Final year of statistical projection". The default value is 2020, but any value can be chosen, keeping in mind that the accuracy of cubic spline projection decreased further into the future. The first year of projection is the start year of the Spectrum projection, but the projected indicators are only recorded from 1990 onward, in correspondence with the availability of WHO TB data.

- **Number of splines**: The more splines covering the projection interval the greater the ability of the cubic spline to respond to sharp changes in data. However, more parameters introduce the risk of over-fitting the data, producing unreliable projections beyond the years of available data. Tests with the TIME Estimates model suggest that 9-11 basis function are sufficient to fit most indicators.

- **Smoothness penalty**: This setting allows the user to control the influence of the smoothness penalty as per equation 5. Reducing the penalty will allow greater flexibility in fitting data, but will lead to uncontrolled projections beyond years of data. As with the number of basis functions, a subjective judgment must be made regarding the compromise between fitting more data points versus producing smooth future projections.

- **'Order' of Smoothness penalty**: This setting controls the type of penalty that is imposed on the projection. A 'first order' penalty favors a projection which is smooth. Mathematically it penalizes large difference between adjacent cubic spline coefficients. A 'second order' penalty favors a projection that follows recent trends in the data. Mathematically it penalizes large second-order differences between adjacent cubic spline coefficients.

- **Uncertainty interval**: The checkbox "Estimate uncertainty intervals" is used to toggle between having uncertainty intervals or not. When selected, a specified "Number of bootstraps" is used to generate the uncertainty interval, which represents a 95% confidence interval for the indicator. The more bootstraps used, the more accurate the final uncertainty intervals, but the longer time requirements for the processing will be.

After setting the parameters for all curves, or accepting the default values (which typically works well), the user must click the "Fit All" button which will process the fitting of all indicators. The Indicator Fitting screen is shown below. At the right bottom are two progress bars to show how the bootstrap sampling method is progressing as it runs for each indicator.

Figure 6: Fit indicators
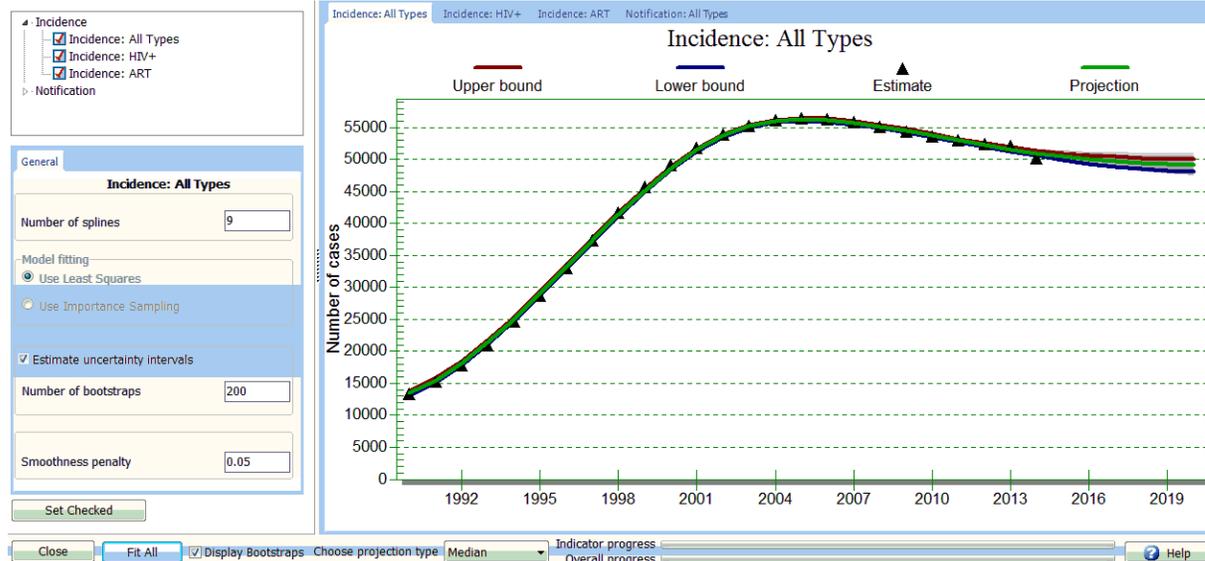
Parameters specific to fitting HIV+ TB incidence

When fitting HIV+ TB incidence, a second set of parameters must be specified, as explained in section "Estimating HIV-TB incidence by CD4 category":

- **RR for CD4 > 500 cells/uL (%)**: This setting sets the risk for TB infection at a specified level relative to the risk for HIV- cases, which is estimated by the algorithm.

- **Increase in RR per 100 uL CD4 decline (%):** This setting controls the exponential increase in risk for TB infection for each 100 uL units of CD decline.

- **Reduction in RR for HIV patients on ART (%):** This setting controls the reduction in risk of TB infections for HIV patients receiving ART.

- **Relative weight of survey, sentinel and routine HIV-TB testing data**. The method simply replicates each dataset, if available, a specified number of times. More weight is typically given to population surveys, being the most unbiased assessment of HIV+ TB incidence. This is a subjective way of ensuring that the final HIV+ TB incidence estimates matches estimates from population surveys as closely as is possible given overall TB incidence and the properties of the HIV+ population (namely CD4 distribution and ART status).

- **Data inclusion threshold:** HIV+ TB incidence estimates obtained from routine testing are typically biased when coverage is low, since under such conditions only the most severe cases are tested. This setting specifies a coverage setting below which to reject routine testing data in the HIV+ TB Incidence estimate.

Figure 7: Fitting HIV+ TB incidence
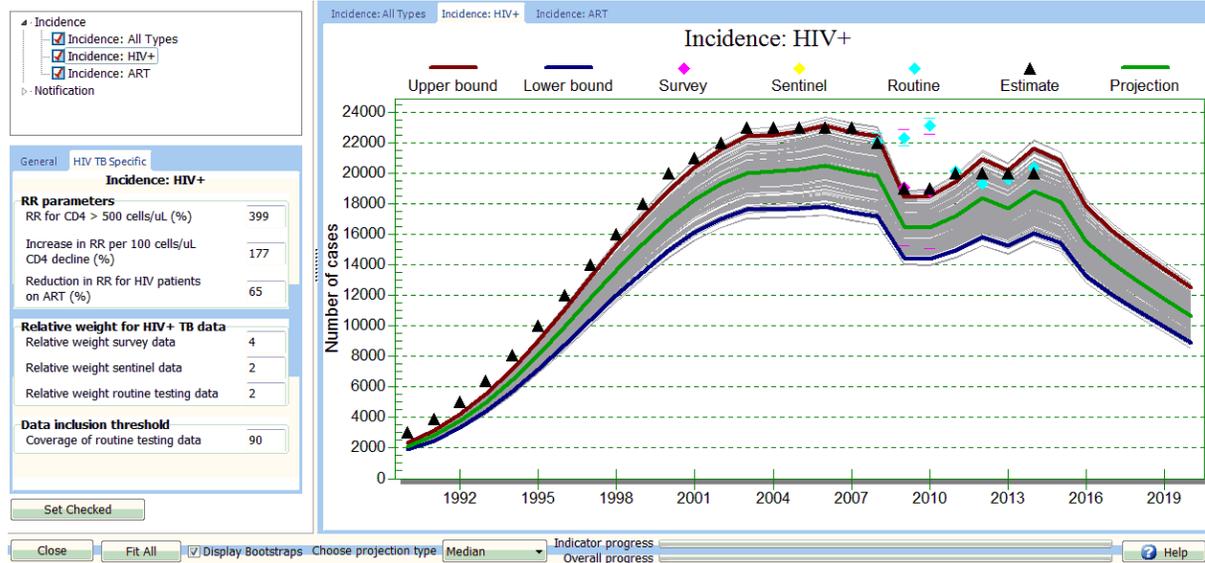
7.7.1.3 Methodology

7.7.1.3.1 Estimating TB indicators with cubic splines

The purpose of this section is to explain the method TIME Estimates utilizes to make projections of TB indicators. All methods are based on using cubic spline projection, and the method is outlined below.

A flexible and relatively simple way to project trends through the indicators under Program Statistics is to represent them as k time-dependent m'th order cubic-spline functions [p.152,3]:

$$I(x) = \Sigma_{i=1 \text{ to } k} \; \beta_i \, B^m_i(x) \qquad (4)$$

where β_i is the i'th spline coefficient and $B^m_i(x)$ represents the evaluation of the i-th basis function at time(year) x. The order of each basis function is m and we use cubic splines, i.e. m=3. Equation 4 simply states that any time-dependent function, such as incidence, can be represented as a linear combination of cubic-spline basis functions.

The values of the cubic-spline coefficients β are determined by an optimization routine which minimizes the least squares error between incidence data (I_{obs}) and the estimated incidence curve I(x):

$$\Sigma_{x=1990:2012} \; |I(x) - I_{obs}(x)|^2 + \lambda\beta^T S\beta \qquad (5)$$

Here $|I - I_{obs}|^2$ is the sum of squared errors in estimated incidence and S is a difference penalty matrix applied directly to the parameters β to control the level of variation between adjacent coefficients of the cubic-spline, and thus control (through a choice of λ) the smoothness of the time-dependent case incidence curve. Another important purpose of the use of the smoothness penalty matrix S is to regularize (by creating smoothness dependencies between adjacent parameters) the ill-conditioned inverse problem (more unknown parameters than the data can resolve) that would tend to over fit the data when left ill-conditioned.

Confidence intervals from cubic-spline projection

The cubic-spline method is then used to fit an indicator (incidence, notification, smear type etc.) to a set of bootstrapped data, obtained by sampling from the normal error distribution resulting from fitting the 'point estimate'. This bootstrap method produces a sample of projected cubic-spline curves that are practically equivalent to a set that would be obtained from fitting the model to the same number of repeated measurements (or assessments) of the given indicator. Confidence intervals based on the bootstrapped data are typically narrow in the years where the model has data to utilize, and 'spread out' after that, following a Gaussian process with an increasing variance.

7.7.1.3.2 Estimating HIV-TB incidence by CD4 category

The disaggregation of TB incidence by CD4 category is based on the idea that increase in the relative risk for TB incidence is a function of CD4 decline. Williams et al captured this idea in a model for the relationship between the RR for TB and CD4 decline [4]. They suggested a 42% (+- 17% for 95% confidence interval) increase in RR for TB for each unit of 100uL CD4 decline.

The Spectrum-TB model's disaggregation method is based on the Williams et al model. The model first estimates HIV- TB incidence and then calculates the 'risk of TB' $F = I^- / P^-$, where I^- is HIV- TB incidence and P^- the number of HIV- individuals susceptible to TB.

An assumption is made that the risk of TB for HIV+ cases with CD4 count > 500 uL is proportional to F (we assume it is higher by a factor of 2.5 [9]). For each 100uL CD4 decline in the remaining categories (350-499, 250-349, 200-249, 100-199, 50-99 CD4 cells/uL, and CD4 count less than 50 cells uL), the risk of TB is represented as:

$$F(c<500) = F(c>500) \cdot p(1) \cdot p(2)^{dc},$$

where p(1) is a parameter that is used to recognize that HIV+ cases with high CD4 counts could be at higher risk of TB relative to HIV-, and p(2) controls the exponential increase in RR with CD4 decline. dc is the number of 100uL CD4 decline associated with the midpoint of each CD4 category relative to 500: dc= (3.0, 4.4, 8.6, 12.9, 19.2, 28.6, 37.3) for the six CD4 categories.

A reduction in RR is applied for those being on ART for more than one year.

Parameter assumptions

- We assume p(1)=2.5 [9] and fit p(2) in order to match total TB incidence and HIV+ TB estimates from HIV-test data where available.

    There are a number of aspects of the RR-approach that has to be balanced: the 'biological meaning' we would like to attach to these parameters and a more straightforward interpretation of these parameters as regression coefficients. Both parameters can be fitted or both can be fixed. Varying at least p(2) seems reasonable, as it captures the variation we expect countries to have with respect to baseline (HIV-negative) CD4 count and it strikes a balance between the biological and regression mechanisms.

- The RR-model is used to estimate TB incidence among ART cases. An estimate for ART-TB is available in the database, and it is arguably not necessary to estimate it with the RR-model, but there are a number of problems with the ART data, the biggest of which is that some countries appear to report cumulative ART numbers, which this method cannot anticipate or handle.

We assume Hazard Ratios (HR) of 0.35 for all CD4 at ART initiation categories. Suthar et al reports HRs of 0.16, 0.35 and 0.43 for those on ART with CD4 count < 200, 200-350 and > 350 [5], and these values could in principle be used. However, Spectrum tracks only CD4 at initiation, thus limiting the use of CD4-specific HR for ART patients.

An assumption is made that the HR of 0.35 applies only to patients on ART for more than 6 months. Spectrum's ART-mortality estimates, derived mostly from ART cohorts in SSA, suggest that mortality is still very high in the first six months of treatment. Since TB is a leading cause of HIV mortality, it was felt that the HR of 0-6 month ART patients is likely still high and reduction factor due to ART is not applied.

Likelihood function

A simple least squares approach is used to fit model to total TB incidence, and to all available estimates of HIV+ TB incidence. These estimates of HIV+ TB incidence are obtained by three sampling methods: population surveys of HIV-TB prevalence (least biased, but scarce due to cost), sentinel HIV data (biases include more testing of advanced HIV) and routine HIV testing of reported active cases (variable coverage). To increase the importance of survey data we include replicas (duplicated it, to be specific) of the survey data in the likelihood function. By this we mean that for years with HIV-test data, we simply add identical copies of the HIV-test data to the likelihood function. This is a way of (subjectively) giving more weight to HIV-test data in the likelihood function, in which function it would be competing with our total TB incidence estimate. The total TB incidence estimate is based on much more data, evenly spread out in the estimation period 1990-2015.

Trial and error shows that using **two** replicates of the HIV survey data (i.e. duplicating the survey data) and of the routine testing estimate with coverage greater than 90%, **for each** a) HIV sentinel and b) routine testing estimate with coverage between 50-90% (0-50% routine testing data are not used), gives a good disaggregation of total TB incidence into HIV+ and HIV- TB, with the fit passing close to survey points where they are available.

For countries with no data we use a range for p(2) estimated from countries with survey data, which suggests that p(2) = 1.96 [1.8-2.1] and fit the RR-model only to total TB incidence. There is no satisfactory way of verifying results for HIV+ TB incidence when no HIV-testing data are available, but comparison of the global estimate for HIV+ TB incidence produced by Spectrum TB and GTB's estimate (based a different method using HIV prevalence instead of CD4 distributions and using the same HIV-test but in a different way) suggests that the RR-model works reasonably well.

7.7.1.3.3 Estimating TB mortality

TB mortality is calculated as product of incidence and case fatality ratios:

$$M = (I-N)F_u + NF_n \qquad (1)$$

where I represents incident TB cases, N cases that are notified, (I-N) TB cases that are not notified and M TB mortality. F_n and F_u are the case fatality ratios for notified and non-notified incident cases respectively.

The following case fatality ratios, obtained in collaboration with the TB Modeling and Analysis Consortium (TBMAC) [6-8], are used in the estimation.

The disaggregation of incident TB is based on the ratio of the point estimate incidence and notified cases, both estimates coming from the TB database. We use a single CFR for all bootstrapped mortality estimates.

7.7.1.4   TIME Estimates results

Results are arranged into the following sections:

TB Epidemiology

- **TB Incidence** – TB incidence by HIV status

- **TB Incidence by CD4 count**: For HIV+ TB incidence a breakdown by CD4 category: CD4 < 250 cells/uL, CD4, 250-350, 350-500 and CD4 > 500 cells/uL

- **TB Notification** – by treatment history and smear type

- **TB Mortality** – by HIV and ART status

MDR burden and mortality

- MDR burden among new (pulmonary) and retreatment notified cases

- MDR mortality

Summary

- A summary table of key TB indicators is available
- A summary table of indicators used by the TB costing module of One Health (OH). These indicators serve as target populations in the OH TB Costing tool.

Display configuration

Each display has several options for configuring the display of results:

- As a line chart or a table of results

- Population denominator: as absolute numbers, per 100, 000 population and per 100 population (i.e. percent)

- Confidence interval: for those indicators with upper and lower bounds, a toggle is available for the display of the indicators

Examples of a TB Display Configuration Editor, a TB Incidence chart and a Summary table are shown below.

Figure 8: CFR estimates by case type: notification, HIV and ART status

Figure 9: Displaying results for TB incidence by HIV status
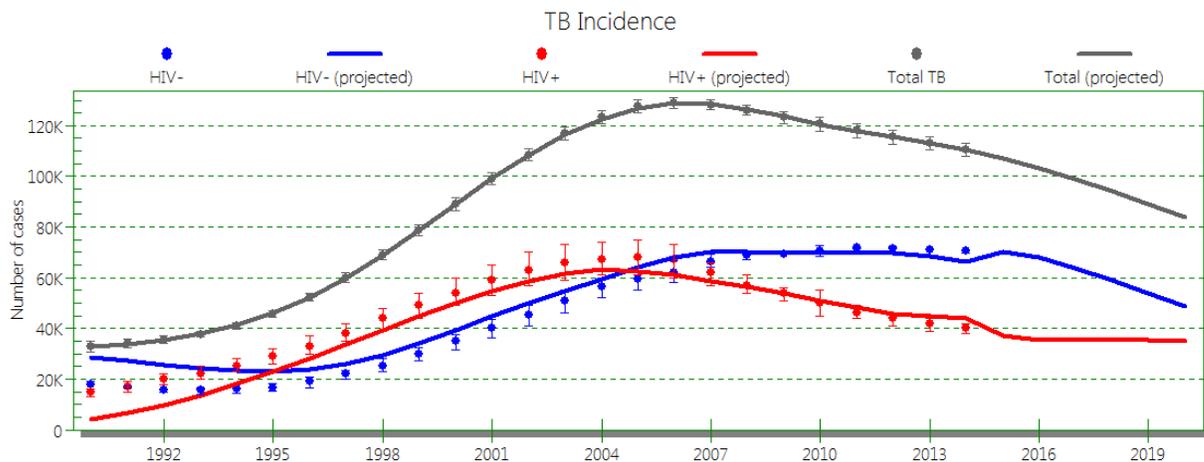
Figure 10: Displaying results for TB incidence by HIV status

Epidemiology summary-Kenya

Epidemiology summary (Number of cases)	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	
TB Incidence													
Total incidence	122,707	126,954	128,843	128,455	126,462	123,578	120,520	117,838	115,426	113,012	110,326	107,111	1
HIV- TB incidence	59,595	64,357	67,807	70,097	70,024	69,911	69,587	69,521	69,821	68,375	66,248	69,957	
HIV+ TB incidence	63,112	62,597	61,036	58,358	56,438	53,667	50,933	48,317	45,605	44,637	44,078	37,154	
Receiving ART more than one year	773	3,005	6,649	12,858	14,089	17,483	18,167	21,809	23,807	22,928	24,503	29,670	
Receiving ART less than one year	1,341	2,039	4,147	1,076	3,204	4,405	5,634	4,404	2,745	2,026	404	73	
Not Receiving ART(by CD4 count)	60,999	57,553	50,240	44,425	39,145	31,779	27,132	22,105	19,054	19,683	19,171	7,411	
> 500	0	0	0	0	0	0	0	0	0	0	0	0	
350 - 500	0	0	0	0	0	0	0	0	0	0	0	0	
250 - 350	0	0	0	0	0	0	0	0	0	0	0	0	
< 250	0	0	0	0	0	0	0	0	0	0	0	0	
Notification													
Total cases (new, retreatment and relapse)	101,923	108,033	111,934	113,447	112,934	110,800	107,448	103,250	98,454	93,275	87,928	82,620	
Pulmonary, bacteriologically confirmed	0	0	0	0	0	0	0	0	0	0	34,997	34,997	
Pulmonary, clinically diagnosed	0	0	0	0	0	0	0	0	0	0	30,872	30,872	
Extrapulmonary	0	0	0	0	0	0	0	0	0	0	14,640	14,640	
Total relapse cases	0	0	0	0	0	0	0	0	0	0	7,516	7,516	

7.7.1.5   References

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[2] Stover J, McKinnon R, Winfrey B. Spectrum: a model platform for linking maternal and child survival interventions with AIDS, family planning and demographic projections. *International Journal of Epidemiology* 2010; 39 Suppl 1:i7–10.

[3] Wood S, Generalized Additive Models. Chapman and Hall (2007)

[4 Williams B, "The impact of ART for HIV on TB" (http://www.who.int/hiv/topics/artforprevention/williams.pdf)

[5] Suthar AB, Lawn SD, del Amo J, Getahun H, Dye C, et al. (2012) Antiretroviral Therapy for Prevention of Tuberculosis in Adults with HIV: A Systematic Review and Meta-Analysis. PLoS Med 9(7): e1001270. doi:10.1371/journal.pmed.1001270

[6] Tiemersma EW, van der Werf MJ, Borgdorff MW, Williams BG, Nagelkerke NJ (2011) Natural history of tuberculosis: duration and fatality of untreated pulmonary tuberculosis in HIV negative patients: a systematic review. PLoS One 6: e17601.

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[8] Mukadi YD, Maher D, Harries A (2001) Tuberculosis case fatality rates in high HIV prevalence populations in sub-Saharan Africa. AIDS 15: 143-152.

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7.7.2 TIME Impact

7.7.2.1 What is TIME Impact?

The TIME Impact module is designed to be a comprehensible TB model that can be used by TB programme planners during policy discussions to help inform strategic planning at the national or sub-national level. The model works in parallel with DemProj, AIM and other modules in Spectrum that are currently used by international organisations to estimate disease burden and plan optimal strategies for a variety of programmes.

The module can be used to generate projections of country-specific TB epidemics, based on country data, in order to investigate the estimated future epidemiological trends under baseline conditions. Following the calibration of a baseline model, the user can then explore the estimated impact of key TB interventions under user-defined scale-up scenarios, in order to help guide policy discussions and provide evidence needed to make informed decisions around prioritisation of interventions. Outputs from TIME Impact can be used to inform costing models for health economic analyses.

TIME Impact is directly linked with official national AIM files, which removes the need to independently calibrate the HIV aspect of the TB dynamical model. This feature is critical for countries with a high HIV TB co-burden, where TB programme planners are interested in studying the impact of HIV interventions on the TB epidemic as well as the epidemiological impact of interventions aimed at HIV-associated TB.

Methods

The methods of the TIME Impact module are fully detailed on the TIME website http://tbmodelling.lshtm.ac.uk/time-projects/. In summary, the model is a dynamical TB model with than 1000 compartments: 2 for sex, 17 for age (5 year bins), 2 for MDR status, 5 for TB status, 2 for treatment history, 3 for ART status and 8 for HIV/CD4 category. It receives demographical information from DemProj and HIV information from AIM, and automatically calibrates a large part of the model's compartments.

Parameters defining TB dynamics are outlined in two section of the TIME Impact module: 'Epidemiology' and 'Care and Control'. These include, but are not limited to, progression to active TB, conversion from smear negative to smear positive, recovery, mortality and treatment success.

7.7.2.2 TIME Impact input editors

7.7.2.2.1 Configuration

General settings

- **Enforce parameter limits**: If users select this option, then the lower and upper bounds are fixed in the Epidemiology editor. If this option is un-ticked, then users can put any value.

- **Transfer Impact to the TB Estimates model**. This setting is in place to facilitate linking TIME Impact to the TB section in the One Health Tool, and enable cost-effectiveness calculations. This section is still under development, and we recommend that users do not apply it at this time.

- **No intervention scale up.** The "No intervention scale-up" setting can be used to keep all intervention in the Care and Control section constant from the **Base Year** onward. The model will always ignore any scale-up beyond the **Target Year**, regardless if the box is ticked.

- **MDR start year** sets the year when MDR is introduced into the TB epidemic. This year is determined by the timing and availability of multiple treatment options, and is different in each country. **MDR initial pulse:** is the fraction of new and retreatment cases that are MDR in the MDR start year.

- **Stop rescaling of TIME Impact population size to match DemProj:** This will stop any adjustment that is made to the demographic model in time in order to match that of DemProj, starting at the year selected from the drop down menu.

- **Stop adjusting DemProj mortality for TB-deaths from TIME:** This will stop adjusting mortality, by re-including TB deaths in background mortality, starting at the year selected from the drop down menu.

Figure 1: TIME Impact - General configuration settings
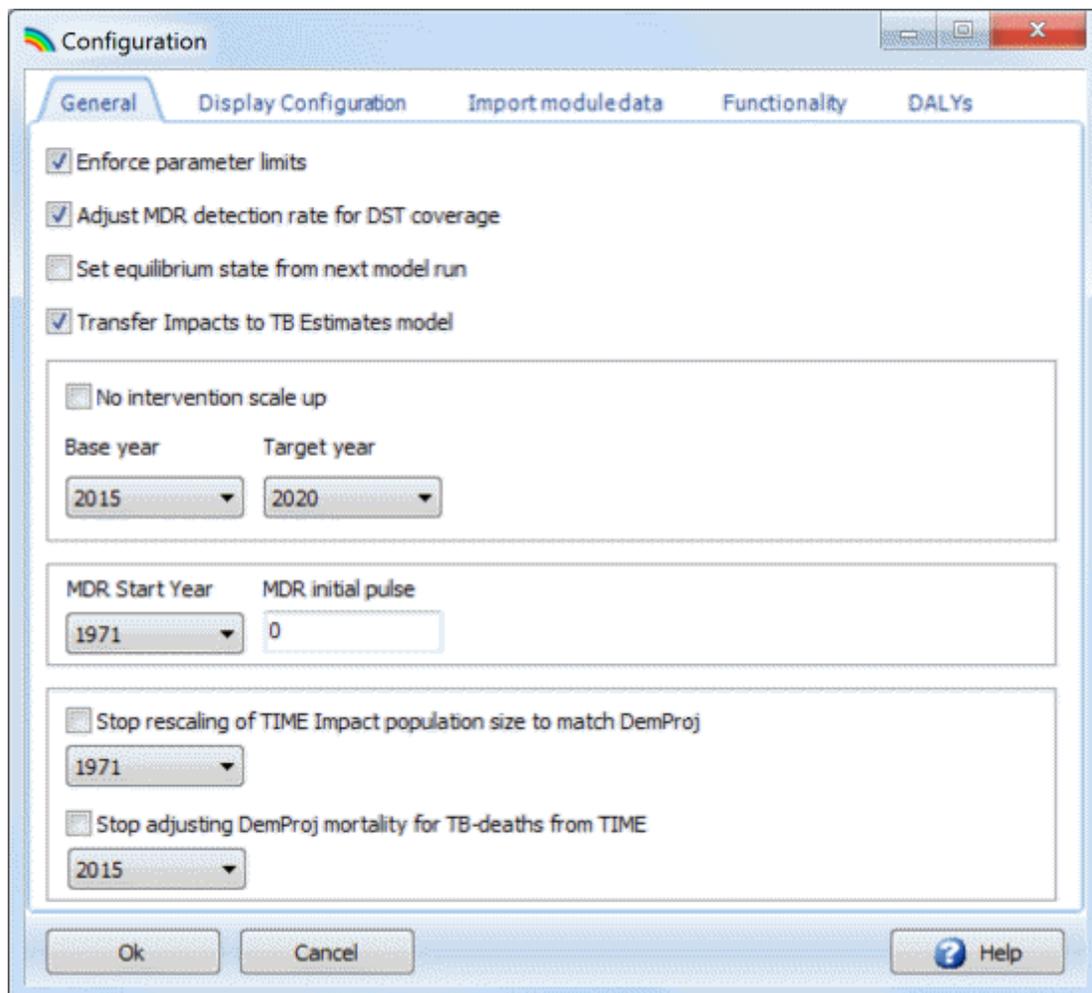
Display Configuration settings

A few settings are available to configure display options:

- **Snap results tables to year:** This year will snap Result Tables as well as Care and Control Tables to a specified year. Since projections often start in 1971, this avoids scrolling over to the right of a table if the present years are of interest.

- **Display reported or projected estimates.** During calibration data from the TIME Estimates are automatically drawn in to aid the calibration of the model. A choice between reported [Estimates (country data)] and projected data (TIME projections) is provided. Reported data runs to the year before the present year, while projected data runs out to the last year of statistical estimation, as set in the TB Estimates model's Configuration editor.

- **Display results for adults only (15+):** this option filters out paediatric (u15) individuals from the model and presents all outputs for adults only.

Figure 2: TIME Impact Display configuration settings
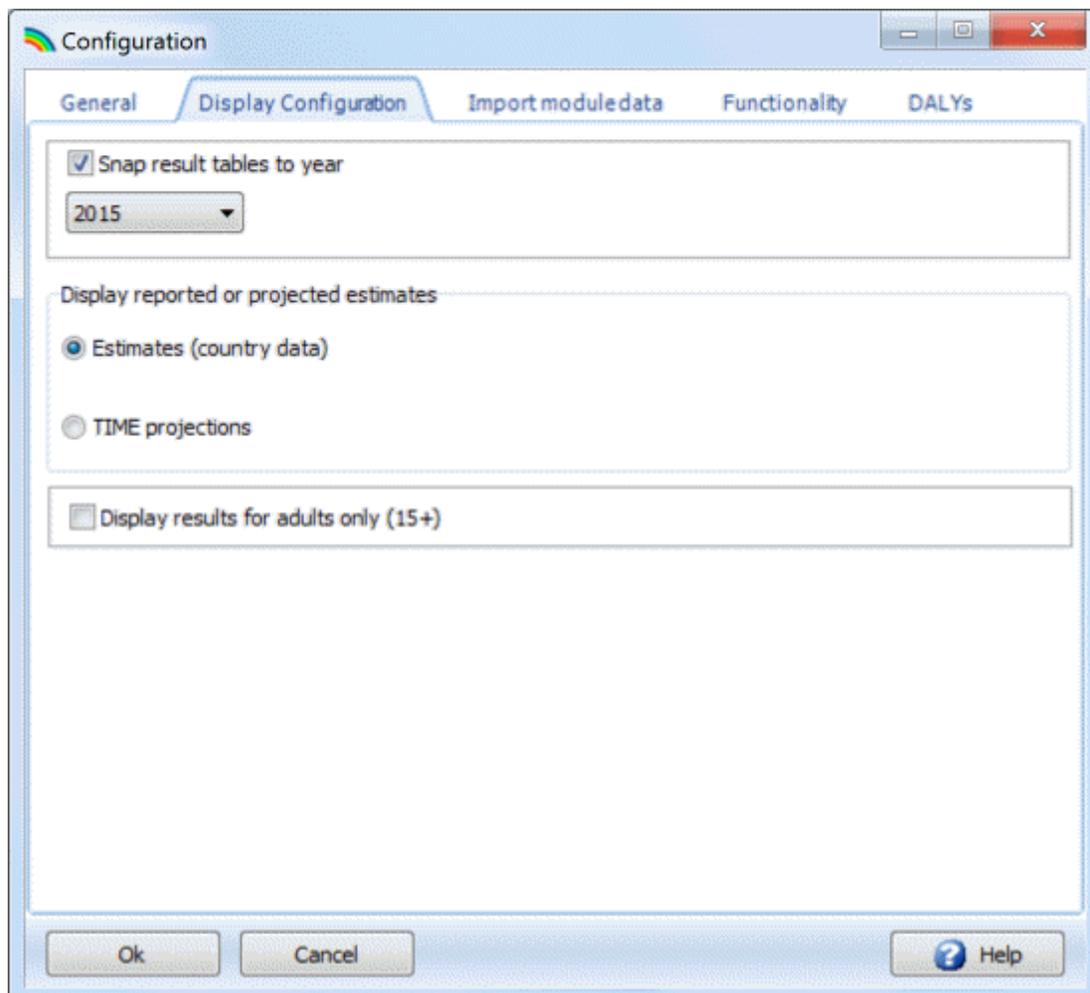
7.7.2.2.2 Epidemiology

Natural History Parameters (by HIV)

These are parameters that are fixed in time for which default values are provided following expert review. These parameters can be edited but are expected to remain relatively constant in different countries and contexts. The parameter values are shown below.

The parameters are divided into HIV- and HIV+ status. At the bottom of the editor are entries for the protective effect of ART in reducing TB incidence and TB mortality.

Figure 3: TIME Impact - Epidemiology - Natural History (by HIV)

| Natural History | Natural History (by year) | CD4-related Relative Risk | Paediatric TB |

Smear status	HIV-	HIV+
cases developing SSpos TB	45.00	32.70
relative infectiousness SSneg TB	22.00	22.00
smear conversion rate	1.50	2.25
Recovery		
self cure rate	20.00	10.00
MDR		
relative fitness of MDR strains	73.00	73.00
rate of acquiring MDR	1.40	1.40
treatment success when using FL for MDR treatment naive	61.00	61.00
treatment success when using FL for MDR previously	45.00	45.00
Protection offered by ART % reduction of impact HIV	Progression	Mortality
ART < 6m	20.40	23.20
ART 7m-12m	55.40	62.90
ART >1 Year	70.00	79.50

Table 1 – Epidemiology – Natural History (by HIV)

The following table provides the values for each editable parameter, including their suggested bounds. Values omitted from this table, are those that TIME Impact calculates based on the RR parameters 1 and 2 (i.e. the HIV+ progression to TB parameters). These values and ranges are based on the literature, and references can be found at the end of this section.

Natural History Parameters	Point estimate	Lower bound	Upper bound
Progression to TB			
HIV-			
Develop Primary TB (%)	11.5	8	15
Reactivation rate (%/year)	0.1	0.01	0.25
Protection provided by prior infection (%)	65	37	90
Risk Ratio parameter 1			

Develop primary TB (%)	2.6	2.11	3.2
Reactivation rate (%/year)	2.6	2.11	3.2
Protection provided by prior infection (%)	0.8	0.6	1
Risk Ratio parameter 2			
Develop primary TB (%)	1.36	1.3	1.42
Reactivation rate (%/year)	1.36	1.3	1.42
Protection provided by prior infection (%)	-1.3	-2	-1
Smear Status			
HIV-			
Cases developing SSpos TB (%)	45	40	50
Relative infectiousness SSneg TB (%)	22	10	37
Smear conversion rate (%/year)	1.5	0.7	3
HIV+ (CD4>500)			
Cases developing SSpos TB (%)	32.7	21.9	42.5
Relative infectiousness SSneg (%)	22	10	37
Smear conversion rate (%/year)	2.25	1.5	3
Recovery			
HIV-			
Self cure rate (%/year)	20	10	25
HIV+ (CD4>500)			
Self cure rate (%/year)	10	6	16

Recovery			
HIV-			
TB morality rate (SSpos) (%/year)	30	20	41
TB mortality rate (SSneg) (%/year)	21	18	25
HIV+ (CD4>500)			
TB mortality rate (SSpos) (%/year)	60	40	82
TB mortality rate (SSneg) (%/year)	42	36	50
MDR			
HIV-			
Relative fitness of MDR strains (%)	73	58	85
Risk acquiring MDR under treatment (% per treatment episode)	1.4	1	1.7
Treatment success when using FL for MDR treatment naive	0.61	0.53	0.70
Treatment success when using FL for MDR previously treated	0.45	0.35	0.58
HIV+ (CD4>500)			
Relative fitness of MDR strains (%)	73	58	85
Risk acquiring MDR under treatment (% per treatment episode)	1.4	1	1.7
Treatment success when using FL for MDR treatment naive	0.61	0.53	0.70
Treatment success when using FL for MDR previously treated	0.45	0.35	0.58

Protection offered by ART % reduction of impact on HIV			
Progression			
ART <6m (%)	20.4	15.75	26.83
ART 7m-12m (%)	55.4	42.75	72.83
ART >1 year (%)	70	54	92
Mortality			
ART <6m (%)	23.2	10.7	27.7
ART 7m-12m (%)	62.9	50.7	75.2
ART >1 year (%)	79.5	64	95

Natural History Parameters (by year)

Parameters for TB progression as well as for TB-related mortality can be specified by year. The user can edit only the values for HIV-negative cases, while the values for HIV-positive cases are calculated and are grayed out.

Figure 4: TIME Impact - Epidemiology - Natural History (by Year)

	1990	1991	1992	1993	1994
Natural History	Natural History (by year)	CD4-related Relative Risk	Paediatric TB		
Progression to TB					
develop primary TB					
HIV–	11.50	11.50	11.50	11.50	11.50
HIV+	29.90	29.90	29.90	29.90	29.90
reactivation rate					
HIV–	0.10	0.10	0.10	0.10	0.10
HIV+	0.26	0.26	0.26	0.26	0.26
protection provided by prior infection					
HIV–	65.00	65.00	65.00	65.00	65.00
HIV+	52.00	52.00	52.00	52.00	52.00
TB Mortality					
TB mortality rate (SSpos)					
HIV–	30.00	30.00	30.00	30.00	30.00
HIV+	60.00	60.00	60.00	60.00	60.00
TB mortality rate (SSneg)					
HIV–	21.00	21.00	21.00	21.00	21.00
HIV+	42.00	42.00	42.00	42.00	42.00

CD4-related Relative Risk

Parameters related to progression to TB disease have additional settings for HIV+ cases. Parameter 1 sets the RR of cases with CD4 count > 500 cells/uL. Parameter 2 sets the exponential increase in RR for each 100 uL of CD4 decline. The result is that RR for primary TB and reactivation of latent TB increases exponentially with declining CD4 count. The protective effect of prior infection decreases exponentially for decreasing CD4 count.

Progression parameters can further vary by time (see Natural History (by year)) and a drop-down list is provided to select the year in order to table the corresponding distribution of values by CD4 count.

Figure 5: TIME Impact - Epidemiology - CD4-related Relative Risk

| Natural History | Natural History (by year) | CD4-related Relative Risk | Paediatric TB |

Relative Risk Parameters	param 1	param 2
develop primary TB	2.60	1.36
reactivation rate	2.60	1.36
protection provided by prior infection	0.80	-1.30

2016

Progression to TB	> 500	350 - 500	250 - 349	200 - 249	100 - 199
develop primary TB	29.9	37.7	55.4	69.8	87.8
reactivation rate	0.3	0.3	0.5	0.6	0.8
protection provided by prior infection	52.0	42.7	30.7	25.2	20.7

Childhood TB

On the Childhood TB tab users can make changes to the paediatric parameters of the epidemic. Users can modify the Relative Risks for developing primary TB in the 10-14 age group and the rest of the parameters will change accordingly.

Users also have the option to include the effectiveness of a country's BCG vaccination programme by ticking the **BCG Vaccination** box underneath the table. This box shows a default percentage; however the model will not take this into account unless the BCG Vaccination box is ticked.

Figure 6: TIME Impact – Paediatric TB

| Natural History | Natural History (by year) | CD4-related Relative Risk | Paediatric TB |

2016	10-14	5-9	0-4
Relative Risks			
develop primary TB	0.47	1.18	2.22
cases developing SSpos TB	0.22	0.11	0.18
TB mortality rate (SSpos)	1.00	1.00	2.00
TB mortality rate (SSneg)	1.00	1.00	2.00
Childhood TB parameters (Percent)			
develop primary TB	5.41	13.57	25.51
cases developing SSpos TB	9.94	4.86	8.04
TB mortality rate (SSpos)	30.00	30.00	60.07
TB mortality rate (SSneg)	21.00	21.00	42.05

☑ BCG Vaccination

56 Effectiveness (Percent)

Table 2 – Epidemiology – Paediatric TB

Parameter and age group	RR	Paediatric risk
Risk of rapid progression		
10-14 years old	0.47 (0.4-0.69)	5.4%
5-9 years old	1.18	13.6%
0-4 years old	2.22	25.5%
Risk of smear positivity		
10-14 years old	0.67	30.2%
5-9 years old	0.34	15.3%
0-4 years old	0.02	0.7%
Mortality rate, Smear positive		
10-14 years old	1	30
5-9 years old	1	30
0-4 years old	2	60
Mortality rate, Smear negative		
10-14 years old	1	21
5-9 years old	1	21
0-4 years old	2	42

Another important parameter in paediatric TB is protection offered by BCG in vaccinated children. Overall (extrapulmonary and pulmonary) weighted average of BCG protection is 56.24% (39%-72%)

Reference:

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7.7.2.2.3 Care and Control

Care and Control parameters

These are time dependent parameters which are varied to reflect country-specific situations: case detection, linkage to care, treatment success and the effective contact rate. The first three are determined by a country-specific TB Care and Control program while the effective contact rate depends on the mixing in the population, e.g. social contact rates. A distinction is made between non-MDR and MDR Care and Control parameters. The contact rate does not vary by MDR status.

The parameters in the Care and Control editor are divided into the following tabs:

1) **Screening:** this shows the parameters for the screening rates and sensitivity and specificities of implemented diagnostic pathways. Users need to make use of an external workbook to calculate the sensitivity and specificities of the diagnostic pathways.
2) **Non-MDR:** this shows care and control parameters for non-MDR TB cases. Users can edit in Table or Charts. If the "use logistic curves" button in the Charts editor is clicked, then users cannot model in the Table editor and must use the logistic curve function in Charts.
3) **MDR:** this shows care and control parameters for MDR-TB cases. Users can edit in Table or Charts.
4) **MDR Case Detection:** This holds the DST coverage by HIV status and treatment status over time. Users can edit in Table of Charts.
5) **ART Program:** this editor allows users to input parameters about ART program coverage and is divided into three tabs:

- **Adult ART:** users can specify the method of ART coverage entry by selecting one of the following options: number or percent, CD4 by percent, CD4 by number. The data provided here is emulated from AIM and the two data tables are linked. Data in AIM will be updated based on changes made in TIME Impact and vice versa.
  The table in this editor displays:

i. the **number of adults receiving ART** by gender and the total number of adults receiving ART, by year

ii. the **percentage of adults in need of receiving ART** by gender and by year

iii. the **calculated number of TB patients needing ART** (up to 31st December of each calendar year) by gender, and the total calculated number of TB patients needing ART (up to 31st December of each calendar year), by year

- **Child ART:** this editor displays the following parameters for TB patients aged 0-15 years by year: number receiving cotrimoxazole

6) **Effective Contact Rate:** this shows the average number of individuals one smear positive TB case would infect in a totally susceptible population per unit time.

"**Duplicate first year value**" option: by selecting this option users can duplicate the first year values of all care and control parameters to all years. A warning message will pop up explaining this to the users; the warning message will also explain how to duplicate the values of a specific care and control parameter.

An example of care and control parameters are shown below. A setting is available to set values at all years equal to the values at the first year of the projection. This option is particularly useful during the calibration stages, when different values are investigated for obtaining an endemic equilibrium fit.

Figure 7: TIME Impact - Care and Control Parameters

| Screening | non-MDR | MDR | MDR Case Detection | ART Program | Effective Contact Rate |

| Table | Charts |

	1970	1971	1972	1973	1974	19
Screening Rate						
HIV-						
Rate	45.0	46.6	46.9	47.2	47.5	4
HIV+						
Rate	45.0	46.6	46.9	47.2	47.5	4
Relative screening rate smear negative						
non-MDR						
Percent	40.0	40.0	40.0	40.0	40.0	4
MDR						
Percent	40.0	40.0	40.0	40.0	40.0	4
Relative screening rate for TB-susceptible population	1.5	1.5	1.5	1.5	1.5	
Sensitivity and specificity for case detection						
HIV-						
Smear positive net sensitivity	57.8	57.8	57.8	57.8	57.8	5
Smear positive net specificity	99.8	99.8	99.8	99.8	99.8	9
Smear negative net sensitivity	24.0	24.0	24.0	24.0	24.0	2
Smear negative net specificity	94.0	94.0	94.0	94.0	94.0	9
HIV+						
Smear positive net sensitivity	57.8	57.8	57.8	57.8	57.8	5
Smear positive net specificity	99.8	99.8	99.8	99.8	99.8	9
Smear negative net sensitivity	24.0	24.0	24.0	24.0	24.0	2
Smear negative net specificity	94.0	94.0	94.0	94.0	94.0	9

7.7.2.2.4 Intervention

In the Interventions editor users can model the impact and coverage of specific interventions. The following tabs are available: Impact, Active case finding, Paediatric TB Interventions,

Implementation/Coverage. When modelling interventions, the user will need to work through the necessary tabs from Impact to Implementation/Coverage.

The following pre-defined interventions are included in TIME and can be modelled through the Interventions editor:

1. Increased case detection (non-MDR)
2. Increased treatment success (non-MDR)
3. Improved diagnosis and increased treatment success (MDR)
4. Introduction of Xpert (for smear negative)
5. Active case finding in the general population, by HIV and ART status.
6. Provision of preventive after active case finding in the general population, by HIV and ART status
   a. HIV-negative: short course preventive therapy
   b. HIV-positive, on or off ART: continuous preventive therapy with isoniazid
7. Paediatric interventions: household screening for active cases and provision of preventive therapy to under-5s of household contacts.
8. HIV testing and ART initiation

The following tabs are found in the interventions editor:

1. In the **Impact** matrix users can modify the impact the following interventions have on the model parameters specified in the column headings:

1.1 **Increased case detection (non-MDR):** users can specify by what % the diagnostic rate amongst non-MDR TB cases is changed.

1.2 **Increased treatment success (non-MDR):** users can change the proportion of treatment success for non-MDR TB cases.

1.3 **Improve diagnosis and increase treatment success (MDR):** the user can specify by what % the diagnostic rate for MDR TB cases and their linkage into care is changed

1.3 **Preventive therapy for HIV negative:** users can change the protective efficacy of preventive therapy in HIV negative individuals.

1.4 **IPT for HIV positive individuals on and off ART:** users can change the protective efficacy of isoniazid preventive therapy in HIV positive individuals on and off ART.

Figure 8: TIME Impact – Interventions - Impact matrix

	Epidemiology			Diagnostic Rate			Linkage into care		Treatment Success		
	% reduction in risk primary TB (HIV+)	% reduction reactivation rate (HIV+)	% latent to susceptible	Relative detection rate smear neg	non-MDR	MDR	non-MDR	MDR	HIV-	HIV+	HIV+ on ART
Increased case detection (non-MDR)					50.0						
Increased treatment success (non-MDR)									50.0	50.0	50.0
Improved diagnosis and increased treatment success (MDR)						50.0					
Preventive Therapy for HIV neg			80.0								
IPT for HIV+ on and off ART	35.0	35.0									

2. Users can change the following model parameters in the **Active Case finding** matrix: HIV/ACF option, Sensitivity of screening algorithm, Frequency of screening, ACF linkage to care and treatment success relative to passive diagnosis, and the option to include preventive therapy as part of the campaign, including the sensitivity of LTBI test.

Figure 9: TIME Impact – Interventions – Active case finding

	HIV-	HIV+ not on ART	HIV+ on ART
HIV-ACF option	☑	☑	☑
Sensitivity of algorithm (%)			
Detection rate smear pos	80.0	80.0	80.0
Relative detection rate smear negative	40.0	40.0	40.0
Sensitivity for MDR	30.0	30.0	30.0
Frequency of screening			
Number of campaigns per year	1.0	1.0	1.0
Duration of campaign (months)	3.0	3.0	3.0
Interval between campaigns (months)	9.0	9.0	9.0
Continuous	☐	☐	☐
ACF linkage to care and treatment success			
Relative linkage to care and treatment success (%)	100.0	100.0	100.0
Preventive Therapy	☐	☐	☐
Sensitivity of LTBI test	80.0		

3. In the **Paediatric TB Interventions** users can change model parameters related to household screening of notified cases and the provision of preventive therapy to under 5 years old, regardless of LTBI status (ie. No screening in under 5 year olds). These are: average household size, the proportion of household members who are under 5 years of age, the proportion of household members under 5 years of age with LTBI in a household with an active TB case, the proportion of other household members with active TB, and the sensitivity of ACF for household screening algorithm.

Figure 10: TIME Impact – Interventions – Paediatric TB Interventions

Average household size	4.2
Proportion of household that is u5	15.7
Proportion of u5s with LTBI in HH with active case	30.4
Proportion of other HH members with active TB	4.5
Sensitivity of ACF for HH screening (%)	
Detection rate smear pos	80.0
Relative detection rate smear neg	40.0
Sensitivity for MDR	30.0

4. In the **Implementation/Coverage** interface users can model the scale-up of implementation and coverage parameters for the interventions discussed above, over time.

Users can also change model parameters related to IPT for HIV positive cases not on ART and on ART. These include coverage of INH and the proportion that default from ART/INH annually.

Parameters for household screening interventions are also shown on the Implementation/Coverage interface: coverage of household screening of notified TB cases, the proportion that linked to IPT care, the proportion of cases under five years of age that complete IPT.

Finally, users can change model parameters about HIV testing and ART initiation.

Figure 10: TIME Impact – Interventions – Implementation

Impact Active case finding Paediatric TB Interventions	Implementation				
	2109	2110	2111	2112	2113
Coverage of increased case detection (non-MDR)	0.0	0.0	0.0	0.0	0.0
Coverage of increased treatment success (non-MDR)	0.0	0.0	0.0	0.0	0.0
Coverage of improved diagnosis and increase treatment success (MDR)	0.0	0.0	0.0	0.0	0.0
Coverage of introduction of Xpert (for smear negative)	0.0	0.0	0.0	0.0	0.0
Active case finding					
Coverage in HIV-	0.0	0.0	0.0	0.0	0.0
Coverage in HIV+ not on ART	0.0	0.0	0.0	0.0	0.0
Coverage in HIV+ on ART	0.0	0.0	0.0	0.0	0.0
Preventive Therapy for HIV-					
Proportion that complete diagnosis	0.0	0.0	0.0	0.0	0.0
Proportion linked to LTBI care	0.0	0.0	0.0	0.0	0.0
Proportion that complete treatment	0.0	0.0	0.0	0.0	0.0
IPT for HIV+ not on ART					
Coverage of INH	80.0	80.0	80.0	80.0	80.0
IPT for HIV+ on ART					
Coverage of INH	80.0	80.0	80.0	80.0	80.0
Household screening					
Coverage of household screening of notified TB cases	0.0	0.0	0.0	0.0	0.0
Proportion of u5s linked to PT	0.0	0.0	0.0	0.0	0.0
Proportion of u5s that complete PT	0.0	0.0	0.0	0.0	0.0
HIV testing and ART initiation					
Coverage of HIV testing	80.0	80.0	80.0	80.0	80.0
Proportion linked to ART	100.0	100.0	100.0	100.0	100.0

7.7.2.3   Calibrating an Impact model

The TIME Impact module is first run to demographical equilibrium, i.e. long enough for a stable age distribution to emerge, using the models Natural History and first year's Care and Control parameters. Also used here is the first year's demographical mortality and fertility information. TB is then introduced and the model is run until it is run into equilibrium in the first year of the Spectrum projection.

This is the initial condition for the first year of a Spectrum projection with TIME. Between the first and the final year HIV and MDR TB is introduced, and the model is calibrated to TB trends from the TIME Estimates model. This process establishes a baseline TB module. After this step, the user can scale-up key TB interventions and study and impact relative to the baseline model.

There are several configuration options which influence the calibration and use of a TIME Impact model. The General and Display Configuration settings must be reviewed and possibly adjusted during the calibration steps for a given model. The following steps are typical of a model calibration process.

Step 1

Since the TB module uses information from DemProj and AIM, it is critical to verify that these modules have realistic default values. These models are populated with the most recent data from the United Nations Population Division and UNAIDS respectively. These data are generally reliable, but validation is always a necessary step.

Step 2

Accept the default Natural History and Care and Control Parameters and run the TIME Impact model. Compare its incidence and notification to the results of the TIME Estimates model.

Adjust the Care and Control parameters (first) and Natural History parameters (if necessary) until exponentially growing incidence and notification trends meet projected trends from the TIME estimates model. This should happen after 1990 and ideally before 2000-2005, the year when GTB data is available and arguably reliable respectively.

Step 3

Formulate a given TB control strategy:

Increase the coverage of the relevant line in the Intervention Implementation/Coverage editor after the base year of intervention. Any intervention with a coverage change after the configurable base year will have an impact on a given care and control parameter as specified in the Impact tab.

Users can also model interventions by modifying the Care and Control parameters directly after the base year of the intervention.

Step 4

Observe the impact of the intervening actions by comparing results to baseline.

7.7.2.4 TIME Impact results

In the Results editor, users can visualize the projections by selecting the following options:

1) **TB Epidemiology**: TB incidence, TB mortality, TB prevalence, TB notifications, TB self-recovery. Each of these indicators can be shown according to HIV, Smear, Treatment history or MDR status. Data for calibration, from TIME Estimates, is shown where available. The section also displays the Annual Risk of TB Infection (ARI) by MDR status.

   Finally, this result section shows detection ratios:

   Case Detection Ratio = [Total notification] / [Total incidence]
   Case Fatality Prevention = [Total notifications] / [Total (notifications + TB deaths + TB self-recoveries)]

Case Finding Proportion = [Total (notifications + self-recoveries)] / [Total (notifications + TB deaths + TB self-recoveries)]

2) **Paediatric TB**:

- Proportion of all TB cases that occurs in under 15 year olds.
- Proportion of all paediatric TB that occurs in under 5 year olds.

TB incidence, TB mortality and TB prevalence can be displayed for each of these indicators.

3) **Post-Preventative.** This section displays the size of the population in post-preventative categories.

4) **TB Case Type**. This section displays information that comes from TIME Impact model, which provides an insight in TB epidemic behaviour as estimated by the model.
- Percent of population that have latent TB
- Percent of active case that follow recent (re) infections
- Percent of active cases that are smear positive
- Percent of active cases that are treatment naïve (i.e. 'new cases')

Each of these indicators can be shown according to HIV and MDR status.

- Proportion of incident cases notified (by HIV status, by smear status and by MDR status).
- Proportion of prevalent cases notified (by HIV status, by smear status and by MDR status).

3) **MDR-TB:**

- MDR-TB Prevalence
- MDR-TB Notifications

Both these indicators can be displayed for new and retreated cases.

4) **Costing items.** This section has three subsections:

- Diagnostics: newly diagnosed cases are shown by smear status
- Treatment: cases notified for treatment, by treatment history (i.e. by new and re-treatment status) and LTBI treatment initiations.
- Screening**:** Holds indicators related to screening and testing of TB cases and susceptible population. These indicators are used to evaluate diagnostic programs.

5) **TB-HIV.** This section has two subsections:

TB-HIV:
- Number of HIV+ TB cases
- Number of HIV+ TB cases enrolled in ART
- CD4 distribution of primary TB, re-infection and re-activation

HIV population (15+):

- HIV population by ART
- HIV prevalence
- Number of new ART patients
- CD4 distribution not on ART and CD4 distribution on ART

These results aid the validation of the HIV sub module of TIME, which is designed to follow AIM closely but which cannot match it exactly. However, from the point of view of HIV-TB, the HIV sub module has been verified to model the HIV epidemic adequately.

6) **Demography**
   This section shows the total population as compared to DemProj. The TIME Impact model uses values from DemProj to calculate the population. Note that there will be minor discrepancies between TIME Impact and DemProj because of different size of the age bins (5-year in TIME Impact, 1-year in DemProj), but the match is adequate to allow interpretation of the results.

   Several displays are available to evaluate the key age-distributions of TIME:

   - Total population
   - HIV Population
   - Active TB population

   The following age and sex-stratified demographic and TB indicators can be found in this section:

   - Total population
   - Total deaths
   - HIV population
   - TB incidence
   - TB prevalence, HIV negative
   - TB prevalence, HIV positive not on ART
   - TB prevalence, HIV positive on ART

   Monitor:

   - Percentage of total population -14 years
   - Average age of active TB case
   - Proportional adjustment to total population

7) **DALYs**

   - DALYs (Disability Adjusted Life Years)
   - YLD (Years Lived with Disability)
   - YLL (Years of Life Lost)

8) **Multiple projections**: This feature allows users to present a variety of indicators from different projections simultaneously (provided they are opened). Indicators include:

   - Incidence
   - Prevalence
   - Mortality
   - Notifications (true positives only)
   - Disability Adjusted Life Years (DALYs)

9) **Summary**: A single table with all information can also be produced. The table also provides a summary of MDR TB by Treatment History and HIV status. Diagnostic and Treatment Notifications (true positives only) are similarly summarized.

10) **Screening Summary**: A single table with all information related to screening results as listed in **Costing Items\Screening**

7.8 NCD
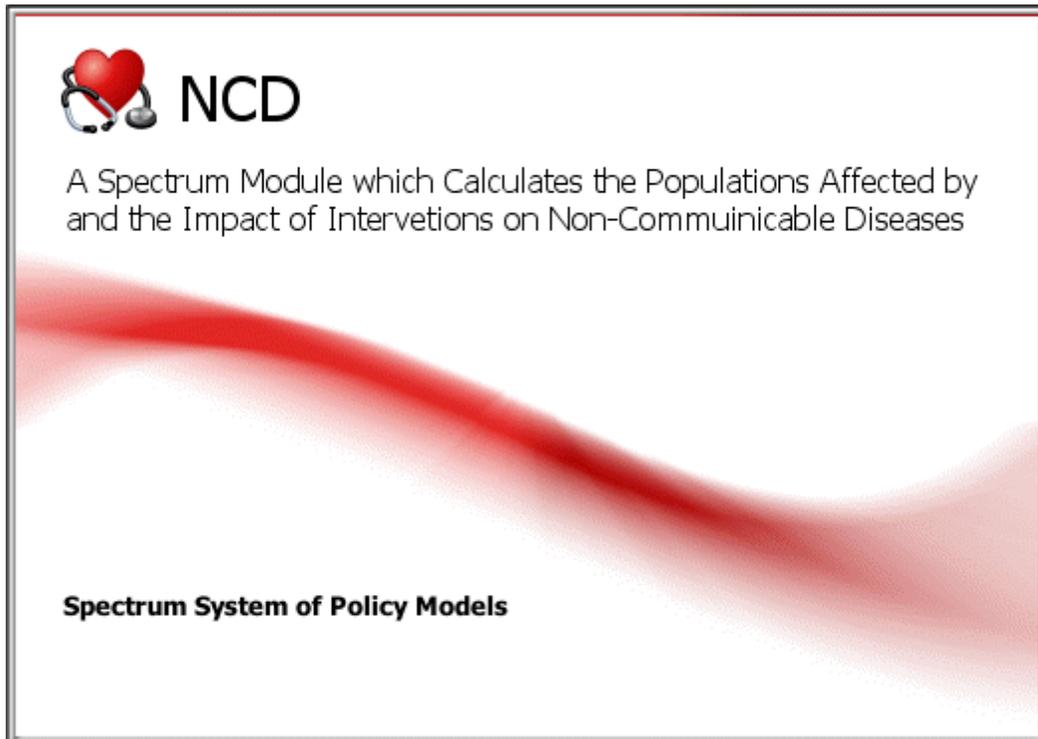
7.8.1 What is NCD?

The Noncommunicable Diseases (NCD) module uses a 'relational' design implementation for different NCD modules. Each NCD model is represented in a collection of tables, and relationships between tables, much like a relational database. The tables are ultimately defined in excel workbooks called "Association Files", one for each NCD and one for each sex and each region, which are read by the NCD model in order to populate the interfaces of the NCD module.

The NCD module consists of a list of NCDs, Health States, Transition Rates, Risk Factors and Interventions. Preventative and treatment interventions are handled separately. Various objects are constructed to draw associations between these lists. For example, that a Health State can belong to more than one NCD (e.g. the disease-free state is part of all NCD modules and stage 1 is part of all cancer NCD models). A Risk Factor can impact on a Transition Rates from a particular Health State in different NCDs. A Prevention Intervention can impact a given Risk Factor or a Treatment Intervention can impact a given Transition Rate of a given Health State of a particular NCD. All such associations are handled by appropriate association objects as defined in the association file of each NCD.

7.8.2 NCD input editors

7.8.2.1 Configuration

The Configuration editor is meant for settings that pertain to all NCD models. For example, the user can set an interventions scale-up, start- and end-date, which will then be applied to all interventions for all

NCDs. If this option is unchecked, intervention specific values will be applied, as defined by the association file and which can be edited and changed in the intervention editor.

7.8.2.2 Select an NCD

This dropdown list is used to select an NCD from the list of available NCDs. The selected NCD will be loaded into the parameter edit and result display screens.

7.8.2.3 Epidemiology

7.8.2.3.1 Associated health states

The purpose of the Health State editor is to provide functionality to review and edit NCD epidemiological parameters. This is achieved by listing all 'Health State-association' objects. These are objects defined by a Health State, initial prevalence (per 1000, but Configurable), and a list of Health States to which Transitions are possible. An NCD model is defined by a complete list of such objects.

An example is given below in Figure 1. Here 'Incidence' affects a transition from Disease Free to Acute Stroke and IHD (ischemic heart disease) states. Note that the Susceptible/Disease Free state is not given an initial prevalence. The age-specific populations from Spectrum are allocated to all the Disease States (IHDAcute, StrokeAcute, IHDPostAcute, StrokePostAcute, StrokeIHDPostAcute) in this example) and the remaining population is put in the NCD-free susceptible state. A disability weight, defined in the association file, is associated with each Health State. This information is used to calculate healthy years lived.

Figure1: NCD Health States

7.8.2.3.2 Risk factors

Each Health State of an NCD has a list of recognized Risk Factors which impact a given Transition Rate (e.g. Incidence, Progression, CFR etc). The Risk Factors tab allows the user to view Risk-Factor associations. That is, objects with a given Health State, prevalence of Risk Factor in the population and an impact factor on a particular Transition Rate. In the example below (see Figure 2), Systolic Blood Pressure > 160 mmHG is a risk factor for the Incidence of Acute IHD. A different impact and different initial prevalence of this Risk Factor can be specified for each age group in each Health State association.

The risk factor associations are already defined in each association file where they are applicable. The values are based on WHO reviews. The process of defining risk factors for CVD is explained in CVD risk factors and prevention interventions.

Figure 2: Risk Factor example: Blood pressure risk factor for IHD

7.8.2.4 Prevention and Treatment

There is not always a clear distinction between actions that prevent or treat a given disease. In the NCD module, Prevention Interventions are actions that influence Risk Factors for a disease and Treatment Interventions are actions that influence particular Transitions between Disease States of the NCD in question.

An example of an intervention is shown below in Figure 3: Treating high blood pressure. Hover-over text gives a detailed description of the intervention. For age groups above 25 years, the intervention will have a stated Impact for those receiving the intervention. Individuals receiving the intervention are determined by the prevalence of the associated risk factor (high blood pressure) and the coverage of the intervention. The base year and target year coverage of the intervention can be set, as can be set the year by which scale up should be reached. Four types of scale up strategies can be chosen from a dropdown list: Linear, S-Shaped, Front Loaded and Exponential.

Figure 3: Prevention and Treatment Intervention

7.8.3 Methodology

The current NCD algorithm handles all NCDs in the same way. Without going into details, the method:

- Processes through the list of NCDs.

- Adapts to the number of Heath States defined for a particular NCD.

- Allocates the population at base year to Health States according to initial prevalence of each Health State and allocate remaining population to the Disease-Free State.

- Adjusts 'background' mortality in Spectrum to exclude mortality associated with a given NCD.

- Applies Prevention and Treatment interventions to Risk-Factor and Health-State associations and updating NCD-specific transitions.

- Sends updated model parameters to the NCD processing unit, which then includes them in a simple solver for the system of states and transition between states that are associated with a given NCD.

7.8.4 Estimating the impact of mental health, neurological and substance abuse disorders

Given that most of the observable health effects of mental health interventions relate to improvements in morbidity or disability, as opposed to saving lives, the proposed metric for summarizing these health effects is Healthy Life Years. Healthy Life Years (with and without scaled-up intervention) are computed with reference to standard life tables that are already built into the model, and reflect the time spent by the population in a particular state of health with a known degree of disability.   Implementation or scale-up of an effective intervention in the population reduces the time spent in a disabling state, either by reducing the number of cases with the disorders (e.g. by decreasing the number of new cases or by

increasing the rate of remission), or by improving the level of functioning of people with the condition in question. For example, a key effect of managing psychosis with anti-psychotic drugs and psychosocial treatment is to control symptoms and thereby enhance functioning, while depression treatment mainly has the effect of reducing the duration of an episode (which is equivalent to increasing the remission rate).

7.8.5   NCD results

The following indicators are to be displayed for each NCD:
- Epidemiology
  - o Incidence associated with each Health State (excluding the Disease-Free state)
  - o Prevalence associated with each Health State
  - o Mortality associated with each Health State
- Health Impacts, illustrating the impact of intervention scale up
  - o Healthy Years Lived
  - o Disability Weight
  - o Mortality
- Summary Table

Figure 4: Generating results
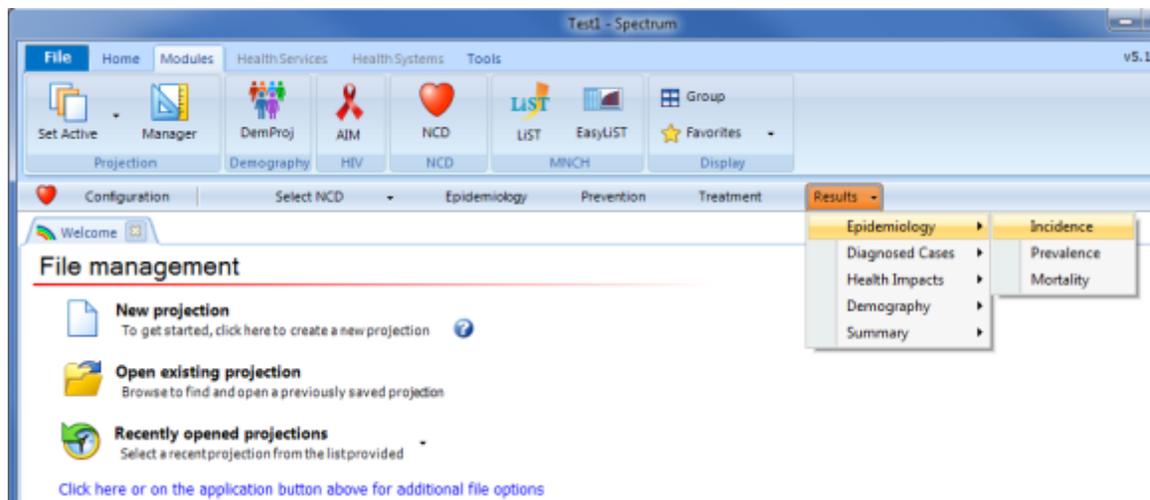
The Epidemiological indicators are displayed as absolute numbers or relative ratios, for example, per 1,000, per 100,000 which can be selected in the Population Index section of the Configuration Editor. The ratio can be taken with respect to the total population or the relevant health-state specific population, by selecting the corresponding option in the Denominator section of the Configuration Editor (Figure 5):

Figure 5: Configuration Editor
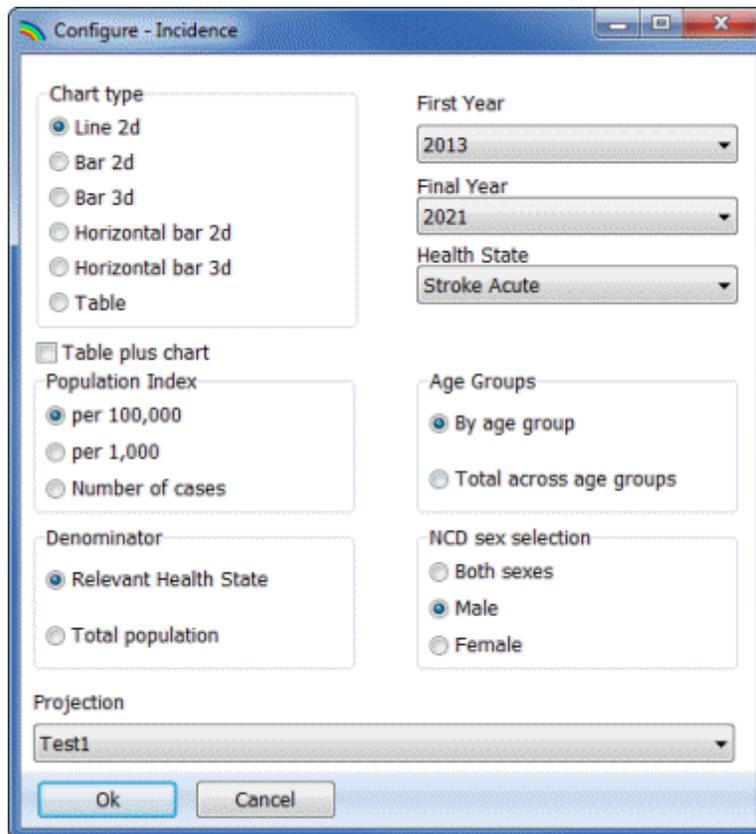
There is also display entry to show basic demography relative to the demographical projection from Spectrum (DemProj). This display is intended to help validate the correctness of each NCD as a simple demographical model, with births and (selected) NCD-free mortality coming from Spectrum, relative to the complete Spectrum demographical model.

7.8.6 Risk factors for Cardiovascular disease (CVD)

7.8.6.1 CVD risk factors and prevention interventions

This section details the assumptions and methods behind the Risk Factor and Prevention intervention association objects of the CVD association files.

Assume that CVD incidence rates are average rates. That is, the incidence rates of ischemic heart disease (IHD) and Stroke in the association file represents rates consistent with an average level of risk (blood pressure, cholesterol, body mass index and smoking) and level of intervention of the population. How do these rates change in response to intervention?

The method used in the Spectrum NCD module calculates the modification in incidence of CVD as an additive modification to the incidence attributable to the proportion of the population with the risk factor.

Consider a general risk factor for CVD. At a given level of intervention coverage, the contribution to total incidence (to Stroke or IHD) is:

$$(1-cov(t_1))*pR*I_0*R^{dB} + cov(t_1)*pR*R^{dB-E}$$

Where:
- $cov(t_1)$ is the coverage of the intervention at t_1
- pR the prevalence of the risk factor
- I_0 the baseline prevalence of the particular CDV incidence
- R is the relative risk of a CVD event for those with the risk factor's per unit increase from a baseline level for the risk factor
- dB is the average number of units above a baseline level for the risk factor
- E is the number of units of recovery towards a baseline level for the risk factor for those exposed to the intervention

Note the term is split between those with the risk factor but exposed or not exposed to the intervention. The average change in incidence following a scale up of the intervention, from $cov(t_1)$ to $cov(t_2)$, is:

$$\text{Change in incidence} = pR* \mathbf{\Delta cov} * I_0 * R^{dB} * \mathbf{(1-R^{-E})}$$

The terms in bold are part of the prevention association object and the non-bold terms are part of the risk factor association object. The term is subtracted from the baseline average incidence rate. When E (the effect of the intervention) is large and the coverage change is also large, the effect will be the removal of the increased risk for those with the risk factor stemming from having blood pressure above a threshold level.

For example, suppose
- the average risk of acute stroke is 1% per year
- baseline systolic blood pressure, below which no reduction in risk is observed, is 120 mmHG
- the prevalence of Blood Pressure > 160 mmHG is 30% and that on average the population has a systolic blood pressure of 165 mmHG, thus 45 units above baseline
- the relative risk for an acute Stroke event is 1.07 for each unit of systolic blood pressure above 120 mmHG
- the change in coverage of an intervention to treat blood pressure is 20% and that it reduces systolic blood pressure by 7 units.

Then the change in incidence I_0 of acute Stroke is

$$0.3* 0.2 * 0.01 * 1.07^{45} * (1-1.07^{-7})=0.048\sim5\% \text{ change in incidence } I_0.$$

The terms in this formulation are all pre-prepared in the CVD association file. The prevalence of risk factors (pR) and the baseline units above threshold (dB) are determined in an external Matlab routine, which estimates the prevalence of risk factors from a defined multivariate normal distribution using random sampling. This multivariate distribution is based on three correlated

risk factors: blood pressure (B), cholesterol (C) and body mass index (BMI). A fourth risk factor, smoking, is also taken into account, but not as part of the multivariate risk distribution.

For each age group, Mean and Variance estimates are specified for B, C, and BMI, together with a Correlation matrix of these random variables. The correlation matrix is particularly important for Total risk calculations. A large number of draws are made from the multivariate distribution with these parameters. This set is used to determine:

- % of individual with B > 160 mmHg, B > 140 mmHg as well the average B for these populations
- % of individual with C > 8 mmol/l, C > 6 mmol/l as well the average C for these populations
- The level of smoking in the age group is applied to the random sample to increase the total risk for those smoking by a specified relative risk parameter for smoking.
- % of individuals with total risk > 20% and < 30% as well as the average B and C for these populations.
- % of individuals with total risk > 30% as well as the average B and C for this population

Total risk is calculated by applying each risk factor as contributing independently to increased incidence. Total risk for stroke, for example, is calculated as $R_{SB}{}^{dB} * R_{SC}{}^{dC} * R_{S\_BMI}{}^{dBMI}$

*Pr(smoking) where R_{SC}, R_{SC} and R_{S_BMI} are relative risk factors for stroke (S) from high blood pressure (B), cholesterol (C) respectively and body mass index (BMI), and dB, dC and dBMI are the units above baseline levels for these risk factors.

This procedure is automated for each risk factor and associated prevention intervention.

The effect of CVD prevention on the incidence of acute stroke is shown below in Figure 6:

Figure 6: Reduction in incidence of acute stroke
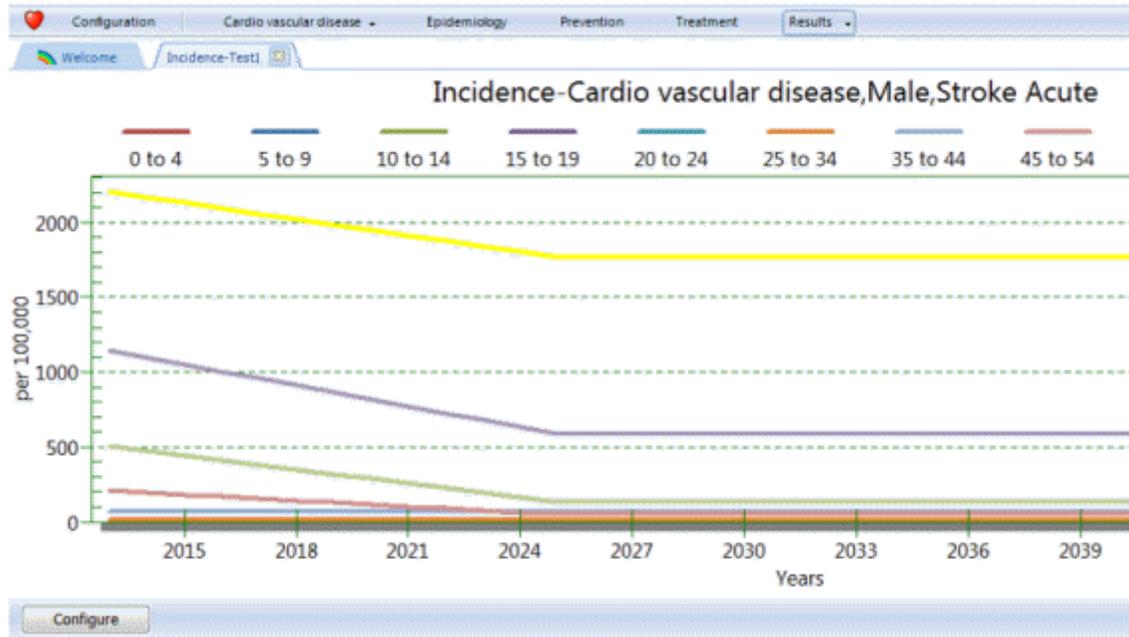
7.8.6.2 CVD treatment

These interventions impact on the case fatality rate (CFR) associated with the post acute stroke or IHD states. The impact on CFR is modeled as:

$$CFR_0 * (1-\Delta cov * E)$$

where

- CFR_0 is the case fatality rate at base year
- Δcov is the change in intervention coverage at time t relative to the base year
- E is the effect of the intervention on decreasing CFR for those exposed to the intervention

The impact of combination drug therapy including beta-blocker, Ace Inhibitor, Statin and Aspirin following AMI on mortality in the post acute stroke health state is shown below in Figure 7:

Figure 7: Impact of combination treatment on post acute stroke mortality
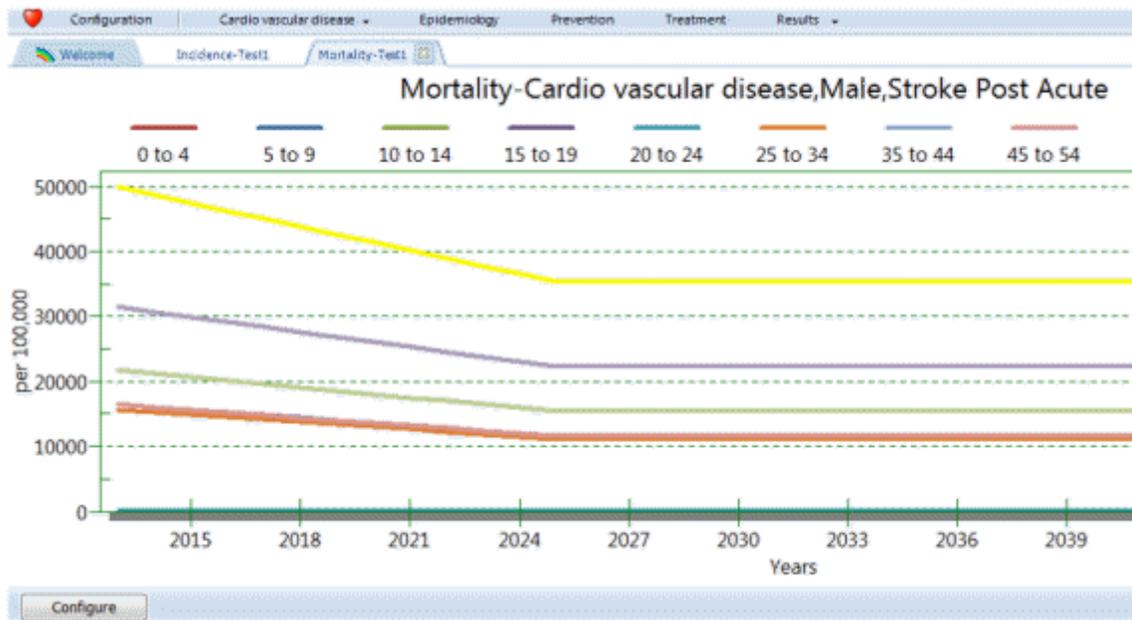
7.8.7 Disability and healthy years lived for MNS disorders

7.8.7.1 Disability weight

There are currently no risk factors and associated preventative interventions for MNS disorders, such as Psychosis, Depression and Epilepsy. A simple device is used to model healthy live years or years lived without disability.

Each episodic MNS health state has an associated disability weight specified in the association file for the MNS disorder. For MNS disorders a special intervention is created to affect the transition called "function" to a state called "disability". These are fictitious association and they do cause individuals to 'move' to a special health state. A special check is put in place to ensure that such an association's only effect is to reduce the disability weight associated with an episodic health state. This effect is illustrated below in Figure 8:

Figure 8: Adjusting disability weights for MNS disorders

7.8.7.2 Healthy years lived

Healthy years lived (HYL) at time t are estimated as follows:

HYL(t,S)=P(t,S)*(1-DW(t,S)) where

- P(t,S) is the prevalence of state S at time t
- DW(t,S) is the disability associated with state S at time t and is adjusted from a baseline value as specified in the association file, during period of expansion of interventions that reduce disability

Total HYL at time t is given by

$$HYL(t) = \Sigma_S \; HYL(t,S)$$

Figure 9 below shows the increase en HYL following an intervention of, for example, "Intensive psychosocial intervention and anti-psychotic medication".

Figure 9: Healthy years lived

7.9 RAPID

7.9.1 What is RAPID?

The socioeconomic impacts model in Spectrum, known as RAPID, is a computer program for making projections of social and economic indicators for countries or regions. The program requires information

on various social and economic indicators, such as the labor force participation rate, the primary enrollment rate, and the number of nurses per capita, to name a few. This information is then combined with population projections (created in the DemProj module of Spectrum) to project the future requirements of the indicators for as much as 50 years into the future.

The RAPID model is intended to provide projections that can be used as the basis of a policy presentation to stimulate policy dialogue about the importance of population factors to social and economic development (Note, however, that there is much more to a successful policy dialogue activity than just the application of the RAPID model.) Such presentations are usually intended to increase policymakers' awareness of population factors in order to improve the policy environment for effective population programs. As a result, RAPID presentations are designed to convey key information to policymakers in a form appropriate for them.

The entire process of developing a RAPID presentation requires a number of steps, including identifying key audiences and messages, collecting socioeconomic development data, making projections, preparing and testing a presentation, developing a booklet to accompany the presentation, training presenters, developing and implementing a dissemination plan, and monitoring and evaluating results.

A typical RAPID presentation includes sections on demographic background, population projections, social and economic impacts, and population program options. RAPID presentations typically examine socioeconomic impacts in education, economy, labor force and new job requirements, health, urbanization, agriculture, and the environment and natural resources. However, presentations must be tailored to each country situation. Therefore, some applications will include additional special sections such as migration, fuel wood, deforestation, water use, land degradation, etc.

RAPID stands for Resources for the Awareness of Population Impacts on Development. The RAPID model was originally developed in 1978 under a contract funded by USAID (RAPID I). Both the model and the presentations have been continuously updated and improved since then. Presentations based on the RAPID model have been made to cabinet-level officials in over 40 countries, including 15 heads of state. The capability to develop and disseminate RAPID presentations has been institutionalized in a number of countries. In many of these countries, continuous dissemination activities have brought information about population programs to thousands of influential individuals at the national and local levels.

RAPID (and the entire Spectrum system of models) is designed to produce information useful for policy formulation and dialogue within a framework of computer programs that are easy to use. The focus is on generating information useful for policy and planning purposes rather than on carrying out detailed research into the underlying processes involved. For this reason, RAPID uses data that are readily available to policy analysts. It requires little demographic or socioeconomic expertise beyond what can be acquired by reviewing and using these manual.

7.9.2   Why make socioeconomic projections?

Socioeconomic projections are useful for a variety of purposes. The RAPID model is designed to make projections that will be useful in stimulating policy dialogue and formulation. Projections can be useful at several stages in the policy process.

1. In the **problem-identification stage,** projections can demonstrate the magnitude of current problems, the likely future magnitude of these and other problems, and the effects of problems in one sector on other development sectors. These projections are used primarily to make people aware that certain problems exist.

2. In the **agenda-setting stage**, projections can be used to show the importance of particular problems in order to encourage decision makers to put the problems on the policy agenda.

Problems then can be matched with other items already on the policy agenda and policymakers can be encouraged to address them.

3. In the **policy-solution stage,** projections can be used to illustrate the effectiveness of proposed solutions in order to generate a consensus around effective actions.

4. In the **policy-participation stage,** policy presentations that include projections can be used with a variety of stakeholders in order to widely disseminate information about problems and proposed solutions. When conducted early in the process, such activities can broaden the participation in defining those problems and solutions. After new policies and programs have been adopted, these activities can be used to explain the new policies and generate support for them.

Socioeconomic projections are also required for planning. All national development plans contain future estimates of a nation's needs for new jobs, teachers, schools, doctors, nurses, urban housing, food, etc. The RAPID model is not intended for preparing detailed planning projections, as it focuses on relatively simple projection techniques that are easily communicated to policymakers. Such projections do have a role in long-term planning, however.

Often, alternative socioeconomic projections are made to show how various rates of population growth would affect the projections. For example, an analysis of the impacts of population growth on education typically would include a high-growth projection (to show the magnitude of the problem under current conditions), and a low-growth projection (to show how a slower-growing population would put less pressure on the education system to meet national education goals). The RAPID model makes it easy to generate alternative projections once the basic assumptions have been agreed upon.

7.9.3   Steps in making socioeconomic projections

There are nine key steps in using the RAPID model to make socioeconomic projections. The amount of time spent on each step may vary, depending on the application, but most projection activities will include at least these nine steps.

1. **Prioritization of population policy issues.** Defining the country's critical problem areas helps focus the data collection efforts and develop meaningful presentations.   The RAPID module currently contains indicators for five sectors: economy, education, health, urbanization and agriculture. Within each of these sectors, however, it is important to select indicators that will be useful in planning or for highlighting potential future problem areas.   For example, in Egypt, it would be appropriate to make projections about future water supply and demand. In Tanzania, the destruction of forests might be a more appropriate indicator. Sectors can be added to the RAPID model as required for particular applications.

2. **Select geographic area.** Socioeconomic projections are normally done at the national level. However, projections may also be done for other geographic areas such as urban areas, capital cities, provinces, districts, and catchment areas. For example, the trend toward decentralization of public programs in many countries has greatly increased the need for projections at the district and provincial level. The first step in making a socioeconomic projection is to decide the most appropriate geographic area for the application.

3. **Determine the period of the projection.** Socioeconomic projections start at some base year and continue for a certain number of years into the future. The base year is often selected on the basis of data availability. The year of the most recent census or large-scale survey is normally selected for the base year of the projection. The number of years to project is determined by the use of the projection. Planning activities generally focus on short-term

projections (5 years) while projections used for policy dialogue often use a longer time horizon (10-30 years).

4. **Collect data.** Data must be collected for each of the assumptions underlying the socioeconomic projections.   Since the projections will only be as good as the data on which they are based, it is worth the effort to collect and prepare appropriate and high-quality data before starting the projection.

5. **Make assumptions.** Socioeconomic projections require that estimates be made about the future levels of the equation's underlying assumptions. These assumptions should be carefully considered and based on reasonable selection guidelines.

6. **Use model.** Once the base year data are collected and decisions are made about projection assumptions, RAPID can be used to enter the data and make the socioeconomic projections.

7. **Examine projections.** Once the projection is made, it is important to examine it carefully. Careful examination of the indicators can act as a check to ensure that the base data and assumptions were understood and were entered correctly into the computer program. This careful examination is also required to ensure that the consequences of the assumptions are fully understood.

8. **Make alternative projections.** Many applications require alternative socioeconomic projections, as described at the end of Chapter I. Once the base projection has been made, the program can be used to quickly generate alternative projections as the result of varying one or several of the projection assumptions.

9. **Disseminate findings.** Once the projections are made, it is important to disseminate them to policymakers. Typically, the projections form a part of a policy presentation that is used to stimulate policy dialogue about key issues. Projection results may also be disseminated through policy booklets, conference papers, and other publications.

7.9.4   Before you get started

First, you will need to run DemProj, part of the Spectrum system of policy models; please refer to its manual for more information. Then you will need to collect data and make certain decisions before running the model. For example, you will need to decide the following at the very beginning:

- whether to include all the sectors available in this model: economy, education, health, urbanization, and agriculture
- whether to include all the variables for each sector, as described below.

You will need to collect data before running the model. For example, the data you may need to include:

For the economy:

- labor force participation rate for males aged 10-14 and 15-64
- labor force participation rate for females aged 10-14 and 15-64
- base year gross domestic product
- annual growth rate in GDP percentage

For education:

- age of entry into primary school and secondary school

- number of years of primary and secondary schooling
- primary and secondary school enrollment rate
- students per primary and secondary teacher
- students per primary and secondary school
- recurrent expenditure per primary and secondary school student

For health:

- population per doctor, nurse, health center, hospital, and hospital bed
- annual health expenditure per person

For urbanization:

- percent of urban population in major city
- persons per urban household

For agriculture:

- arable land (in million hectares)
- base year production of major crop (thousand metric tons)
- annual growth in production of major crop (%)
- annual per capita consumption of major crop (kilograms)

7.9.5   RAPID input editors

This section of the help focuses on presenting the socioeconomic indicators currently contained in the RAPID module. These indicators are broken down into five major sectors: economy, education, health, urbanization, and agriculture. While additional sectors and indicators can be added to the RAPID module, this section only considers those currently contained in the system. The general description, methodology, the equation(s) can be found under Methodology. The inputs and sources (where data underlying the assumptions might be found) are given for each indicator in the following help sections.

Whenever you enter data for a new projection or edit the assumptions, RAPID will note that the data have been changed. The next time you try to display an indicator, it will inform you that the data may have changed and ask if you want to recalculate the projection. Normally, you should answer "Yes" to this question. RAPID will then make the population projection. This message will occur if you edit any of the RAPID or DemProj information, since a change to the DemProj inputs will affect the population projection and, thus, also affect the RAPID socioeconomic projections. To make the projections may take only a few seconds if you are making only a population and RAPID projection, or could take somewhat longer if you are also making a projection including AIDS or family planning modules. Once the projection is made you will not be asked if you want to project the population again unless you edit the assumptions.

7.9.5.1 Economy

Economy	2011	2012	2013	2014	201
LF Participation Rate (Males 10-14)	13.80	13.80	13.80	13.80	13.8
LF Participation Rate (Males 15-64)	60.10	60.10	60.10	60.10	60.1
LF Participation Rate (Females 10-14)	15.00	15.00	15.00	15.00	15.0
LF Participation Rate (Females 15-64)	62.80	62.80	62.80	62.80	62.8
Base year gross domestic product (GDP Millions) (USD)	6,788				
Annual growth rate in GDP %	7.30	7.20	7.20	7.20	7.2

Ok   Cancel   Duplicate   Interpolate   Source   Help

Labor force participation rate, population aged 10-14

If no data exist for the 10-14 age group, assume it is either 0 (not part of the labor force), or the same as for the population aged 15-64.   The assumption regarding the future labor force participation rate for 10- to 14-year-olds should remain constant unless there is a strong rationale for modifying it (e.g., a new law requiring secondary education will be implemented over the next 10 years), and data are available to support the new assumptions.

Labor force participation rate, population aged 15-64

In most cases the policy presentation will be clearest if the labor force participation rate for the population 15-64 remains constant. There are cases where it will be better to project changes in the participation rate, however. For example, the participation rate may decline if enrollment rates in secondary and higher education are increasing significantly. Participation rates for females may increase if their participation in the formal labor force has been small in the past. Special circumstances might also require special assumptions (e.g., a new law requiring mandatory retirement at age 60 will be implemented over the next 10 years).

Gross domestic product (GDP) and annual growth in GDP

The future annual growth can be based on historic growth patterns in GDP (usually over a 5- to 10-year period), or on target growth patterns (e.g., specified in national 5-year plans for economic growth).   In most cases, the annual growth in GDP will be similar for alternative population projections.

Potential Sources

National labor force surveys, development plans, statistical yearbooks, International Labour Organization's (ILO) *Yearbook of Labour Statistics,*   World Bank's *World Development Indicators*

 National development plans, statistical yearbooks, World Bank's *World Development Indicators*   , International Monetary Fund's (IMF) *Government Financial Statistics Yearbook*

7.9.5.2 Education

Age of entry into primary school

If no data exist for the beginning primary school age, using 6 or 7 is a reasonable assumption. Most countries have children begin their primary school cycle at these ages. The model does not allow the beginning assumption to be modified in the future.

Number of years of primary schooling

If no data exist for the number of years of primary school, using 6 is a reasonable assumption. Many countries have 6 years of schooling in their primary school cycle. The model does not allow the beginning assumption to be modified in the future.

Primary school enrollment rate (%)

The primary enrollment rate is equivalent to the gross enrollment rate, i.e., the total number of primary students divided by the population considered to be of primary school age. The assumption regarding the future primary enrollment rate should remain constant unless there is a strong rationale for modifying it.

Students per primary school teacher

This figure can be taken directly from the sources listed, or it can be estimated by dividing the total number of primary students in a year by the total number of primary teachers in that year. The assumption regarding the future ratio of primary students to primary teachers should remain constant unless there is a strong rationale for modifying it. In many cases, however, as governments attempt to improve their educational systems, they develop target student/teacher ratios in their development plans. In these cases, it is useful to include the targets as assumptions to demonstrate the difficulty in achieving them with continued high rates of population growth.

Students per primary school

This figure can be taken directly from the sources listed, or can be estimated by dividing the total number of primary students in a year by the total number of primary schools in that year. The assumption regarding the future ratio of primary students to primary schools should remain constant unless there is a strong rationale for modifying it. In many cases, however, as governments attempt to improve their educational systems, they develop target student/school ratios in their development plans. In these cases, it is useful to include the targets as assumptions to demonstrate the difficulty in achieving them with continued high rates of population growth.

Recurrent expenditure per primary school student

This figure can be taken directly from the sources listed, or can be estimated by dividing the annual recurrent expenditure for primary education in a year by the total number of primary students in that year. The future recurrent expenditure per primary student should remain constant unless there is a rationale for modifying it. In many cases, however, as governments attempt to improve their educational systems, they want to increase their recurrent expenditure per student to meet specified targets. If available, these targets can be used to demonstrate the additional financial burden associated with continued high rates of population growth.

Age of entry into secondary school

If no data exist for the beginning secondary school age, 12 or 13 is a reasonable assumption. Most countries have children begin their secondary school cycle at these ages. The model does not allow the beginning assumption to be modified in the future.

Number of years of secondary schooling

If no data exist for the number of years of secondary school, 6 is a reasonable assumption; most countries have either 4 or 6 years of secondary schooling. The model does not allow the beginning assumption to be modified in the future.

Secondary school enrollment rate (%)

The secondary enrollment rate is equivalent to the gross secondary enrollment rate, i.e., the total number of secondary students divided by the population considered to be of secondary school age. The assumption regarding the future secondary enrollment rate should remain constant unless there is a strong rationale for modifying it.

Students per secondary school teacher

This figure can be taken directly from the sources listed, or can be estimated by dividing the total number of secondary students in a year by the total number of secondary teachers in that year. The assumption regarding future ratios of secondary students to secondary teachers should remain constant unless there is a strong rationale for modifying it. In many cases, however, as governments attempt to improve their secondary educational systems, they develop target student/teacher ratios in their development plans. In

these cases, it is useful to include the targets as assumptions to demonstrate the difficulty in achieving them with continued high rates of population growth.

Students per secondary school

This figure can be taken directly from the sources listed, or can be estimated by dividing the total number of secondary students in a year by the total number of secondary schools in that year. The assumptions regarding future ratios of secondary students to secondary schools should remain constant unless there is a strong rationale for modifying it. In many cases, however, as governments attempt to improve their secondary educational systems, they develop target student/school ratios in their development plans. In these cases, it is useful to include the targets as assumptions to demonstrate the difficulty in achieving them with continued high rates of population growth.

Recurrent expenditure per secondary school student

This figure can be taken directly from the sources listed, or can be estimated by dividing the annual recurrent expenditure for secondary education in a year by the total number of secondary students in that year. The future recurrent expenditure per secondary student should remain constant unless there is a rationale for modifying it. In many cases, however, as governments attempt to improve their secondary educational systems, they want to increase their recurrent expenditure per student to meet specified targets. If available, these targets can be used to demonstrate the additional financial burden associated with continued high rates of population growth.

Potential Sources

National development plans, statistical yearbooks, educational yearbooks, *UNESCO Yearbook* (United Nations Educational, Scientific, and Cultural Organization)

National development plans, statistical yearbooks, education system yearbooks, *UNESCO Yearbook*

National development plans, statistical yearbooks, education system yearbooks, *UNESCO Yearbook*, World Bank's *World Development Indicators*

7.9.5.3 Health

Health	2011	2012	2013	2014	
Population per doctor	25,246.0	24,333.0	24,333.0	24,333.0	
Population per nurse	4,036.0	4,072.0	4,072.0	4,072.0	
Population per health center	0.0	0.0	0.0	0.0	
Population per hospital	0.0	0.0	0.0	0.0	
Population per hospital bed	0.0	0.0	0.0	0.0	
Annual health expenditure per person (USD)	0.0	0.0	0.0	0.0	

Population per doctor

This figure can be taken directly from the sources listed, or can be estimated by dividing the total population in a year by the total number of doctors in that year. The assumption regarding future population per doctor can remain constant in the future (reflecting a continuation of the current service level of the health system), or can be changed to reflect target ratios in the country's development plans. Setting the future assumptions to reflect target ratios can be useful in demonstrating the difficulty in achieving the goals with continued high rates of population growth.

Population per nurse

This figure can be taken directly from the sources listed, or can be estimated by dividing the total population in a year by the total number of nurses in that year. The assumption regarding the future population per nurse can remain constant in the future (reflecting a continuation of the current service level of the health system), or can be changed to reflect target ratios in the country's development plans. Setting the future assumptions to reflect target ratios can be useful in demonstrating the difficulty in achieving the goals with continued high rates of population growth.

Population per health center

This figure can be taken directly from the sources listed, or can be estimated by dividing the total population in a year by the total number of health centers. The assumption regarding the population per health center can remain constant in the future, or can be changed to reflect target ratios in the country's development plans. Setting the future assumptions to reflect target ratios can be useful in demonstrating the difficulty in achieving the goals with continued high rates of population growth.

Population per hospital

The DemProj module supplies this variable. This figure can be taken directly from the sources listed, or can be estimated by dividing the total population in a year by the total number of hospitals. The future population per hospital assumption can remain constant in the future, or can be changed to reflect target ratios in the country's development plans. Setting the future assumptions to reflect target ratios can be useful in demonstrating the difficulty in achieving the goals with continued high rates of population growth.

Population per hospital bed

This figure can be taken directly from the sources listed, or can be estimated by dividing the total population in a year by the total number of hospital beds. The assumption regarding the population per hospital bed can remain constant in the future, or can be changed to reflect target ratios in the country's development plans. Setting the future assumptions to reflect target ratios can be useful in demonstrating the difficulty in achieving the goals with continued high rates of population growth.

Annual health expenditure per person

This figure can be taken directly from the sources listed, or can be estimated by dividing the annual recurrent health expenditure in a year by the total population in that year.   The future recurrent health

expenditure per person can remain constant, or can be changed to reflect national goals for improving the health care system. As governments attempt to improve their health systems, they may want to increase their recurrent health expenditure per person. Using these targets can be helpful in demonstrating the financial burden associated with high rates of population growth.

Potential Sources

National development plans, statistical yearbooks, health system yearbooks, World Bank's *World Development Indicators*

National development plans, statistical yearbooks, health system yearbooks

7.9.5.4   Urbanization

Percent of urban population in major city (%)

This figure can be taken directly from the sources listed, or can be estimated by dividing the population living in the major city in a year by the total urban population in that year. This assumption may remain constant in the future, or may be changed to reflect migration policies. It may also be changed based on past growth of the major city.

Potential Sources

National development plans, statistical yearbooks, World Bank's *World Development Indicators*

7.9.5.5   Agriculture

Arable land (Million hectares)

The future amount of total arable land usually remains constant. It can, however, be changed to reflect a country's development plans or to reflect changes brought about by nature (e.g., increases in arable land through irrigation schemes, or reductions in arable land due to desertification).   Setting future assumptions to reflect national goals is useful in demonstrating the difficulty in maintaining current arable land per capita ratios with continued high rates of population growth.

Base year production of major crop (Thousand MT)

This figure must be taken directly from the sources listed.

Annual growth production of major crop (%)

This figure can be taken directly from the sources listed, or can be computed from a time series. The assumption regarding the future annual crop production increase can remain constant in the future, or can be changed to reflect a country's agricultural goals. Setting the future assumptions to reflect target goals can be useful in demonstrating that achieving the goals will have little impact on improving the situation in the country, as increases will be used to merely offset the growth in population.

Annual per capita consumption of major crop (KG)

This figure can be taken directly from the sources listed, or can be estimated by dividing the total consumption (or production +/- imports) of the crop in a year by the total population in that year. The future per capita consumption of the crop can remain constant, or can be changed to reflect increases or decreases in individual income.

Potential Sources

National development plans, statistical yearbooks, *Food and Agriculture Organization (FAO) Production Yearbook*

7.9.6   RAPID results

To see the results of the projection, select "Results" from the menu bar.

You will then see a menu showing the options available:

- Economy
- Education
- Health
- Urbanization
- Agriculture

Once you have selected an option, the indicators available for that option will appear. For the Economy option, for example, the screen will appear as shown below.
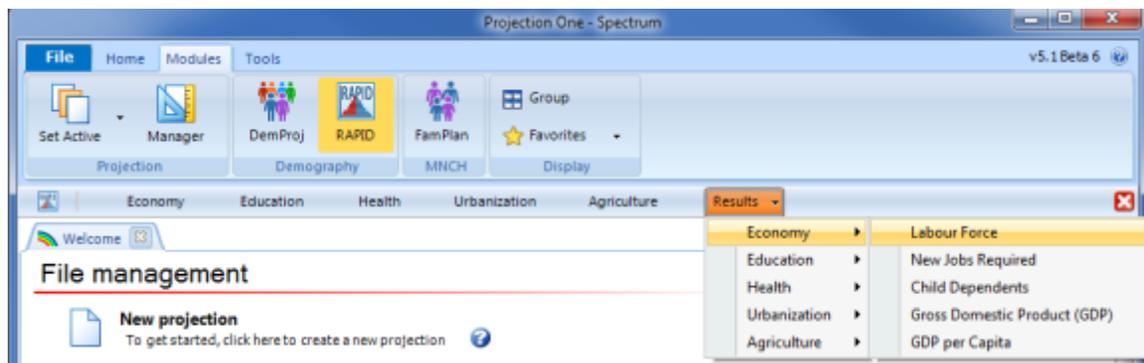
Once you select the indicator to be displayed, you will see the configuration dialogue box. It will look something like the one shown below.
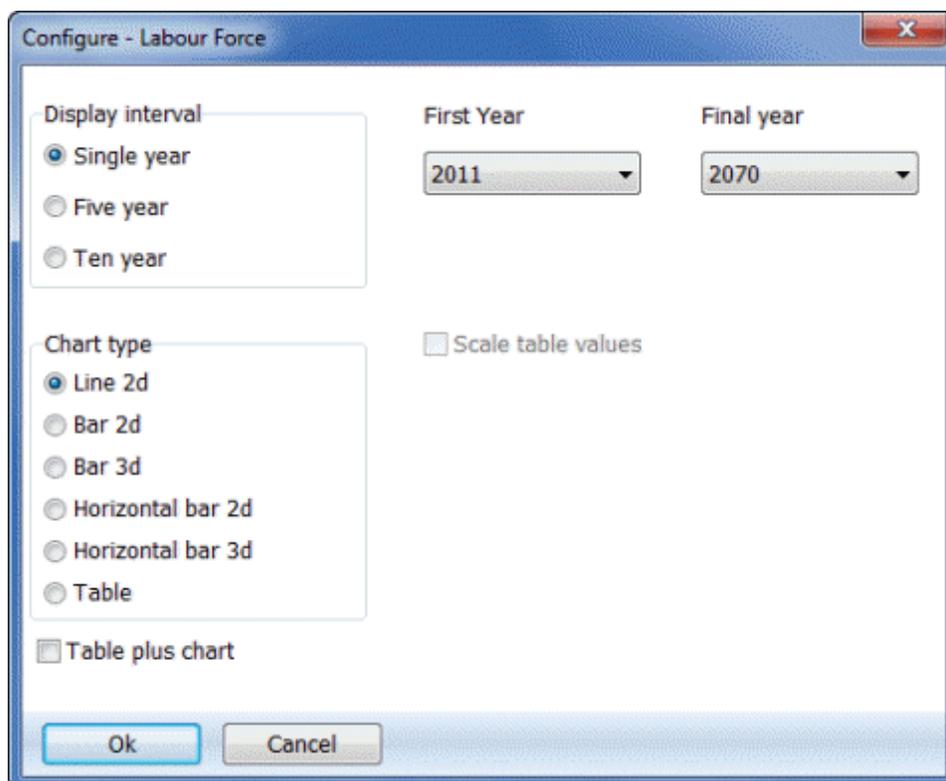
The display will normally be in single years but you can change it to display every five or ten years if desired. The chart type is also set through this dialogue box; click on the button next to the type of display you want. Normally the display will show all the years in the projection. However, if you want to see only part of the projection, you can change the first and final year by selecting a new first and final display year from the dropdown lists provided.

Once you are satisfied with the type of display, click the "Ok" button and the display will appear. (You may also press the "Cancel" button to cancel the display.) It will look something like the display shown below.
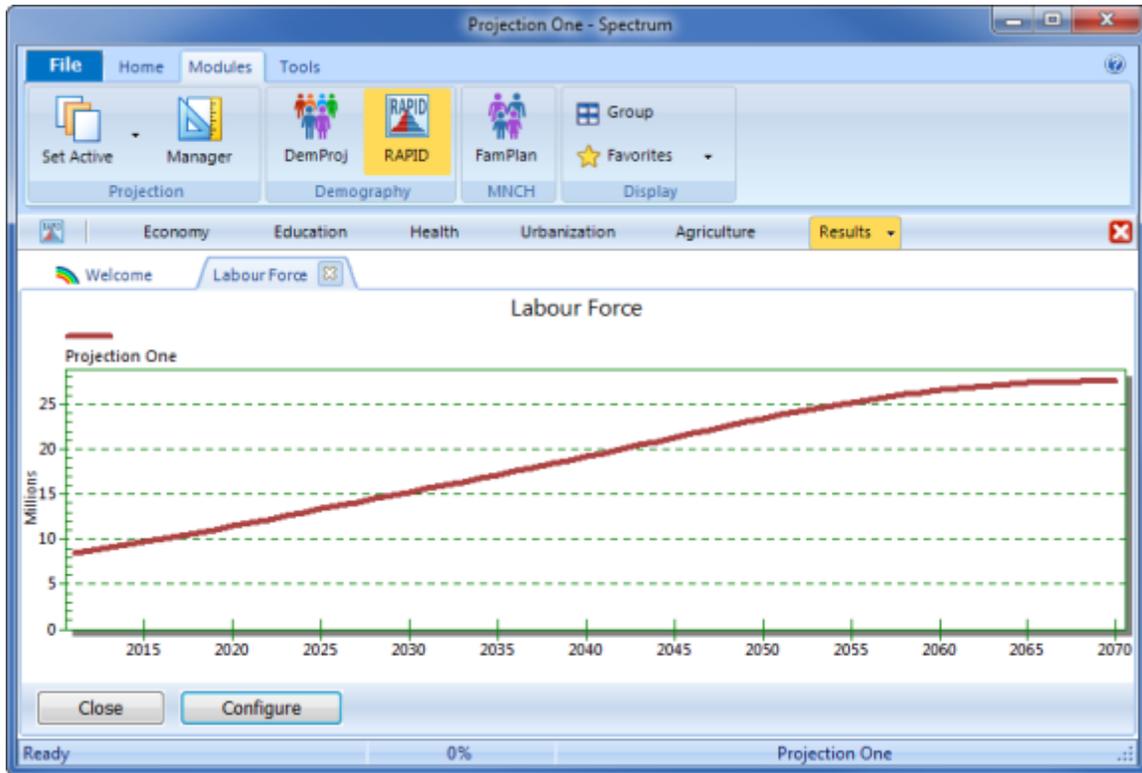
All the projections that are currently in use will be displayed on the same graph.

You can change the configuration of the display by clicking the "Configure" button. You can also change the type of display by putting the mouse pointer anywhere inside the chart and clicking with the right mouse button.

To close the display, click on the "Close" button. You do not have to close the display immediately. You can choose to display another indicator, and it will appear on top of the first display. You can return to any previous display that you have not closed by clicking on the tab associated with that display.

7.9.7 Methodology

The methodology described below assumes that a population projection is available. The population projection is prepared with the DemProj model included in Spectrum. Click here for more information on using the DemProj model to prepare population projections.

Each of the sectors described here uses population projections from DemProj. This section describes the simplest application of the RAPID model, which does not include interactions among socioeconomic sectors or from these sectors back to the population projection. Such interactions may be important in some situations and can be added if needed. The figure below shows these relationships schematically.
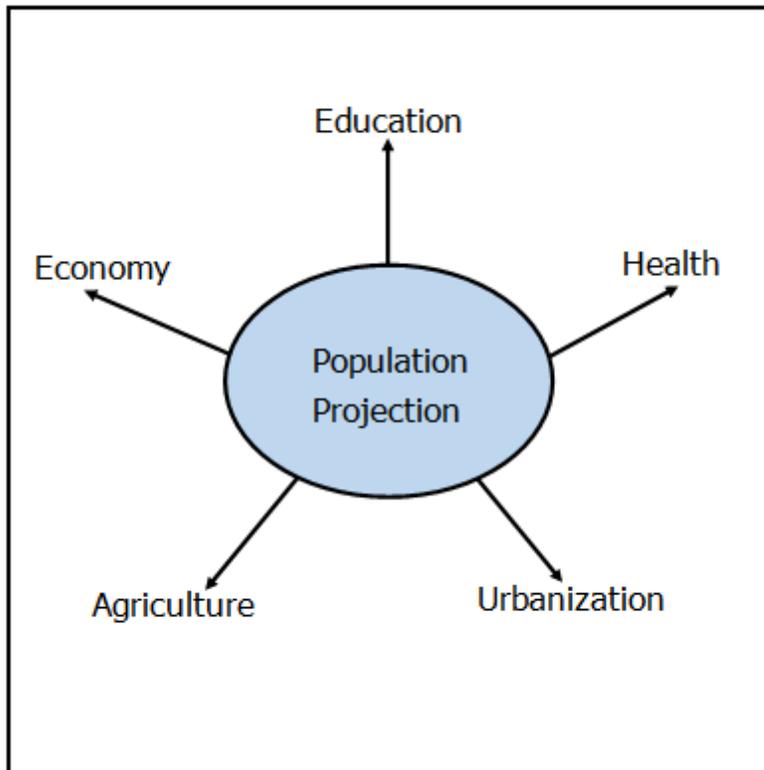
7.9.7.1 Economy

Population growth may affect economic development in a variety of ways. A rapidly expanding population may stimulate demand for goods and services if incomes are also growing, or may reduce per capita income if income grows at a slower pace than the population. Rapid growth of the labor force may provide the labor needed for an expanding economy or may result in more unemployment and underemployment if the rate of new job creation does not match the expansion of the labor force. Savings and investment may be reduced if a greater proportion of output is diverted to consumption to support the larger population. In short, the relationships between population growth and economic growth are many and complex.

There is a large literature on these issues and many economics texts contain extensive treatments of the linkages between population growth and economic development. Several recent studies have found that a reduced rate of population growth has played a key role in the economic development of many Asian countries, such as South Korea, Taiwan, Thailand, Singapore, Indonesia and Malaysia. Specifically, these studies have found that:

- Fertility decline slowed the growth in the number of school-aged children. By keeping educational expenditures high, these countries were able to increase enrollment rates and the quality of education received by each child.

- Savings increased as household size declined. As dependency rates declined, families were able to save more of their income. These savings replaced foreign capital as the major source of domestic investment.

- Fertility decline eventually led to slower growth in the labor force. As a result, both wages and capital investment per worker rose.

For more information on these studies, see the *Proceedings of the Conference on Population and the East Asian Miracle 7–10 January 1997*. For a good summary of recent information on economic growth and population, see Cincotta and Engelman, 1997.

The effect of rapid population growth on economic growth depends on a number of factors. It has been difficult for those who study this relationship to find unambiguous connections because many of the factors that influence economic growth vary across countries just as population growth rates do. The variety of issues that have been studied is illustrated in the following list of questions examined by the National Research Council in a 1986 study (National Research Council, 1986):

- Will slower population growth increase the growth rate of per capita income by increasing per capita availability of exhaustible resources?

- Will slower population growth lead to more capital per worker, thereby increasing per worker output and consumption?

- Do lower population densities lead to lower per capita incomes via a reduced stimulus to technological innovation and reduced exploitation of economies of scale in production and infrastructure?

- Will slower population growth decrease the degree of inequality in the distribution of income?

- Will slower population growth facilitate the absorption of workers into the modern economic sector and alleviate problems of urban growth?

None of these questions has a simple "yes" or "no" answer.

Since many of these issues are too complex to treat in a short policy presentation, the RAPID model uses only relationships that are well understood and easy to describe. The basic model focuses on three basic concepts: dependency, the requirement for new jobs, and per capita output.

Dependency: Dependency is expressed as the number of people in the labor force compared to the number of child dependents. Child dependents are children under the age of 15 who are not in the labor force. The labor force is calculated as the size of the adult population multiplied by the percent that are in the labor force. The projections generally show that the number of dependents is high compared to the labor force when the population is growing rapidly. The ratio of dependents to labor force improves (declines) as the population growth drops. This indicates that more resources are available to support each child when the population growth rate is low than when it is high.

New jobs: New job requirements are calculated as the net growth in the labor force. This includes young people entering the labor force for the first time as well as people leaving the labor force because of retirement or death. When the population is growing rapidly, the number of new jobs required each year also rises quickly. When population growths slows, the number of new jobs required each year generally levels off or declines within 15 years. The 15-year delay occurs because changes in the number of births in one year will not affect the entrants to the labor force until they reach labor force age, about 15.

In economies where underemployment and unemployment are problems, a slower growth in the number of new jobs *required* each year may provide the opportunity for a greater proportion of the population to find productive jobs.

Gross domestic product (GDP) per capita: The relationship between population growth and economic growth is too complex to project with a simple model in a policy presentation. For this reason,

the RAPID model only projects GDP per capita under the assumption that the growth rate of GDP is unaffected by population growth. The annual rate of GDP growth is assumed, usually based on the projected growth in the national development plan or on historical experience. Given the growth rate in GDP, the model projects future levels of GDP per capita. Clearly, in this case, a slower rate of population growth will result in a higher level of GDP per capita. This projection is used to illustrate the fact that growth in per capita income occurs only to the extent that the growth rate of GDP exceeds the growth rate of the population. In countries with high rates of population growth, it may be difficult to achieve substantial gains in per capita income.

7.9.7.1.1 Labor force

The size of the labor force in the future is projected by assuming that a certain percentage of the population between the ages of 10 and 64 will be in the labor force at any time. Therefore, the future labor force size is calculated by multiplying the labor force participation rate for ages 10 to 64 by the size of the population aged 10 to 64. RAPID specifies the labor force participation rates separately for males and females and for the age groups 10-14 and 15-64. Because at any given time, the size of the labor force for the next 15 years already has been determined (i.e., the new entrants have already been born), there will usually be little variation between alternative population projections in the near term based on differing total fertility rate (TFR) assumptions. It is sometimes important to make this point to allay fears that lower fertility will result in immediate labor shortages.

$$LaborForce_t = \sum_s (Pop_{15\text{-}64,t,s} \bullet LFPR_{15\text{-}64,t,s}) + (Pop_{10\text{-}14,t,s} \bullet LFPR_{10\text{-}14,t,s})$$

where:

$LaborForce_t$ = size of the labor force in time t

$Pop_{15\text{-}64,t,s}$ = population of sex s aged 15-64 in time t

$LFPR_{15\text{-}64,t,s}$ = labor force participation rate for population of sex s aged 15-64 in time t

$Pop_{10\text{-}14,t,s}$ = population of sex s aged 10-14 in time t

$LFPR_{10\text{-}14,t,s}$ = labor force participation rate for population of sex s aged 10-14 in time t

7.9.7.1.2 Child dependents

The number of child dependents in the future is projected by adding all the children under age 10 to those aged 10 to 14 who are not in the labor force.

$$ChildDependents_t = Pop_{0\text{-}9,t} + [Pop_{10\text{-}14,t} \bullet (1 - LFPR_{10\text{-}14,t})],$$

where:

$Child Dependents_t$ = children <10 years old plus children ages 10-14 years who are not working at time t.

$Pop_{0\text{-}9,t}$ = population aged 0-9 in time t

$P_{10-14,t}$ = population aged 10-14 in time t

$PR_{10-14,t}$ = labor force participation rate for population aged 10-14 in time t

7.9.7.1.3 New jobs required

The annual number of new jobs required in the future is assumed to be equivalent to the difference in the size of the labor force from one year to the next. It is calculated by subtracting the size of the previous year's labor force from the size of the current year's labor force. This is a net measure of new jobs required. It takes into account new entrants to the labor force and retirements and deaths among current workers. The number of new jobs required is an indicator of the economic growth required to maintain current employment levels. (Note: The number of new jobs required in the base year is assumed to be equivalent to the number of new jobs required in the first year of the projection.)

$$NewJobs_t = LaborForce_t - LaborForce_{t-1},$$

$$NewJobs_1 = NewJobs_2,$$

where:

    $NewJobs_t$ = new jobs required in time t

    $LaborForce_t$ = size of the labor force in time t

    $LaborForce_{t-}$ = size of the labor force in the previous year.

7.9.7.1.4 Gross domestic product

The future gross domestic product (GDP) is calculated by assuming that GDP increases at an exogenously specified growth rate. It is not intended to be a forecast of actual GDP, but is used to demonstrate the impact of population growth on GDP per capita given constant economic growth. (Note: GDP in the base year is entered directly into the model.)

$$GDP_t = GDP_{t-1} \cdot (1 + AnnualGDPGrowth_t),$$

where:

    GDP_t = gross domestic product in time t

    $AnnualGDPGrowth$ = annual growth in gross domestic product in time t

7.9.7.1.5 Gross domestic product per capita

The future GDP per capita is calculated by dividing the projected GDP by the size of the total population. This indicator is intended not to be a forecast of actual economic performance, but rather to demonstrate the impact of population growth on personal economic well-being.

$$GDPPerCapita_t = GDP_t / TotalPop_t \, ,$$

where:

$GDPPerCapita_t$ =   gross domestic product per person in time t

GDP_t =   gross domestic product in time t

$TotalPop_t$ =   total population in time t

7.9.7.2 Education

Education is one of the keys to successful development. Most countries recognize the importance of education and have adopted a goal of universal primary education. The RAPID model addresses this issue by looking at the resources required to achieve national education goals. The inputs to these projections are the enrollment rate goals (usually set out in the national development plan), the number of teachers and classrooms required per student (usually based on current ratios), and the public expenditure per student (usually based on current expenditure rates). RAPID uses these inputs to project the number of primary and secondary school students required in order to achieve the enrollment rate goals. It also projects the number of teachers and classrooms and the expenditures required. These projections are designed to show that huge increases in educational resources are required to achieve national goals when population growth rates are high. The goals are much easier to achieve when population growth rates are slower.

7.9.7.2.1 Children of primary school age

The number of children of primary school age is calculated by summing all children who are of the ages to attend primary school.

$$ChildrenPrimAge_t = \sum_{a=BPA}^{BPA+YrsPrimSchool-1} Pop_{a,t} \, ,$$

where:

$ChildrenPrimAge_t$ =   children of primary school age in time t

$\sum_{a=BPA}^{BPA+YrsPrimSchool-1} Pop_{a,t}$ =   population at beginning primary age (BPA) to population at ending age

BPA   =   age at which primary school normally begins

YrsPrimSchool   =   normal number of years of primary school

7.9.7.2.2 Primary students

The number of primary students is projected by multiplying the number of children of primary school age by the primary enrollment rate.

$$PrimStudents_t = ChildrenPrimAge_t \cdot PrimEnrRate_t \, ,$$

where:

$PrimStudents_t$ = number of primary students in time t

$ChildrenPrimAge_t$ = children of primary school age in time t

$PrimEnrRate_t$ = primary enrollment rate in time t

7.9.7.2.3 Primary teachers required

The number of primary teachers required is projected by dividing the total number of primary students by the ratio of primary students to primary teachers.

$$PrimTeachers_t = PrimStudents_t / StudentsPerPrimTeacher_t,$$

where:

$PrimTeachers_t$ = number of primary teachers in time t

$PrimStudents_t$ = number of primary students in time t

$StudentsPerPrimTeacher_t$ = ratio of primary students to primary teachers in time t

7.9.7.2.4 Primary schools required

The number of primary schools required is projected by dividing the total number of primary students by the ratio of primary students to primary schools.

$$PrimSchools_t = PrimStudents_t / StudentsPerPrimSchool_t$$

$PrimSchools_t$ = number of primary schools in time t

$PrimStudents_t$ = number of primary students in time t

$StudentsPerPrimSchools_t$ = ratio of primary students to primary schools in time t

7.9.7.2.5 Primary education expenditure required

The recurrent primary education expenditure is projected by multiplying the total number of primary students by the average recurrent expenditure per primary student. This indicator is useful in demonstrating the levels of financial resources that will be required to support the primary education system in the future.

$$PrimExp_t = PrimStudents_t \cdot ExpPerPrimStudent_t,$$

where:

$PrimExp_t$ = recurrent primary education expenditure in time t

$PrimStudents_t$ = number of primary students in time t

$ExpPerPrimStudent_t$ = average recurrent primary expenditure per primary student in time t

7.9.7.2.6 Children of secondary school age

The number of children of secondary school age is calculated by summing all children who are of the ages to attend secondary school.

$$ChildrenSecAge_t = \sum_{a=BSA}^{BSA+YrsSecSchool-1} Pop_{a,t},$$

where:

$ChildrenSecAge_t$ = children of secondary school age in time t

$\sum_{a=BSA}^{BSA+YrsSecSchool-1} Pop_{a,t}$ = population at beginning secondary age (BSA) to population at ending age (BSA+YrsSecSchool-1) in time t

BSA = age at which secondary school normally begins

YrsSecSchool = normal number of years of secondary school

7.9.7.2.7 Secondary students

The number of secondary students is projected by multiplying the number of children of secondary school age by the secondary enrollment rate.

$$SecStudents_t = ChildrenSecAge_t \bullet SecEnrRate_t,$$

where:

$SecStudents_t$ = number of secondary students in time t

$ChildrenSecAge_t$ = children of secondary school age at time t

$SecEnrRate_t$ = secondary enrollment rate in time t

7.9.7.2.8 Secondary teachers required

The number of secondary teachers required is projected by dividing the total number of secondary students by the ratio of secondary students to secondary teachers.

$$SecTeachers_t = SecStudents_t / StudentsPerSecTeacher_t,$$

where:

$SecTeachers_t$ = number of secondary teachers in time t

$SecStudents_t$ = number of secondary students in time t

$StudentsPerSecTeacher_t$ = ratio of secondary students to secondary teachers in time t

7.9.7.2.9 Secondary schools required

The number of secondary schools required is projected by dividing the total number of secondary students by the ratio of secondary students to secondary schools.

$$SecSchools_t = SecStudents_t / StudentsPerSecSchool,$$

where:

$SecSchools_t$ = number of secondary schools in time t

$SecStudents_t$ = number of secondary students in time t

$StudentsPerSecSchools_t$ = ratio of secondary students to secondary schools in time t

7.9.7.2.10 Secondary education expenditure required

The recurrent secondary education expenditure is projected by multiplying the total number of secondary students by the average recurrent expenditure per secondary student. This indicator is useful in demonstrating the levels of financial resources that will be required to support the secondary education system in the future.

$$SecExp_t = SecStudents_t \bullet ExpPerSecStudent_t,$$

where:

$SecExp_t$ = recurrent secondary education expenditure in time t

$SecStudents_t$ = number of secondary students in time t

$ExpPerSecStudent_t$ = average recurrent secondary expenditure per secondary student in time t

7.9.7.3 Health

There are a number of ways that population growth affects the health status of the population. Probably the most important relationship is between high fertility and infant, child, and maternal mortality. High fertility is usually associated with short birth intervals, early age at first birth, and many higher-order births. An excellent review of these relationships is contained in *Family Planning Saves Lives* (Shane, 1997). The major conclusions of this review are:

- Closely spaced births result in higher infant and child mortality.

- Spacing births can prevent an average of one in four infant deaths.

- Children born to young mothers are more likely to die.

- Family planning can prevent at least 25 percent of all maternal deaths.

- Family planning prevents maternal deaths from unsafe abortions.

These relationships are the most important health-related issues regarding population growth. They are easily illustrated with data and charts from *Family Planning Saves Lives* and national surveys such as the Demographic and Health Survey (DHS). Most RAPID presentations should contain slides on this topic. However, since a computer model is not required to illustrate these points, they do not form a part of the RAPID module in Spectrum. Instead the model focuses on projecting the increased resources required to maintain or improve health care. The model projects the number of doctors, nurses, health centers, hospitals, and hospital beds required to maintain current per capita ratios or to achieve future goals. It also projects the public expenditure required to maintain or improve health services. These indicators show the increased burden required in all social sectors to keep up with a rapidly expanding population.

7.9.7.3.1 Doctors required

The number of doctors required is projected by dividing the total population by the number of people per doctor. This indicator is useful in demonstrating how the health sector will have to expand in the future

to maintain current levels of health services, both in supporting the current number of doctors and in providing training for new doctors.   Since doctors are not the most common primary health care providers in many developing countries, the number of doctors required might not be an accurate indicator of future health service requirements. In many cases, the number of doctors together with the number of nurses required gives a more comprehensive indication of future health service requirements.

$$Doctors_t = TotalPop_t / PopPerDoctor_t,$$

where:

$Doctors_t$	= number of doctors in time t
$TotalPop_t$	= total population in time t
$PopPerDoctor_t$	= number of persons per doctor in time t

7.9.7.3.2 Nurses required

The number of nurses required is projected by dividing the total population by the number of people per nurse. This indicator is useful in demonstrating how the health sector will have to expand in the future to maintain current levels of health services, both in supporting the current number of nurses and in providing training for new nurses.

$$Nurses_t = TotalPop_t / PopPerNurse_t,$$

where:

$Nurses_t$	= number of nurses in time t
$TotalPop_t$	= total population in time t
$PopPerNurse_t$	= number of persons per nurse in time t

7.9.7.3.3 Health centers required

The number of health centers required is projected by dividing the total population by the number of people per health center. This indicator is useful in demonstrating how the health sector's infrastructure will have to expand in the future.

$$HealthCenters_t = TotalPop_t / PopPerHealthCenter_t,$$

where:

$HealthCenters_t$	= number of health centers in time t
$TotalPop_t$	= total population in time t
$PopPerHealthCenter_t$	= number of persons per health center in time t

7.9.7.3.4 Hospitals required

The number of hospitals required is projected by dividing the total population by the number of people per hospital. This indicator is useful in demonstrating how the health sector's infrastructure will have to expand in the future. Since hospitals are usually restricted to urban areas, however, the number of hospitals required might not be an accurate indicator of health infrastructure requirements. Often, the

number of hospitals together with the number of health centers required gives a more comprehensive indication of future health infrastructure requirements.

$$Hospitals_t = TotalPop_t / PopPerHospital_t ,$$

where:

$Hospitals_t$	=	number of hospitals in time t
$TotalPop_t$	=	total population in time t
$PopPerHospital_t$	=	number of persons per hospital in time t

7.9.7.3.5 Hospital beds required

The number of hospital beds required is projected by dividing the total population by the number of people per hospital bed. This indicator is useful in demonstrating how the health sector's infrastructure will have to expand in the future.

$$HospitalBeds_t = TotalPop_t / PopPerHospitalBed_t ,$$

where:

$Hospitalbeds_t$	=	number of hospital beds in time t
$TotalPop_t$	=	total population in time t
$PopPerHospitalBed_t$	=	number of persons per hospital bed in time t

7.9.7.3.6 Annual recurrent health expenditure

The annual recurrent health expenditure is projected by multiplying the total population by the average recurrent health expenditure per person. This indicator is useful in demonstrating the financial resources required to support the health system in the future.

$$HealthExp_t = TotalPop_t \bullet HealthExpPerPerson_t ,$$

where:

$HealthExp_t$	=	annual recurrent health expenditure in time t
$TotalPop_t$	=	total population in time t
$HealthExpPerPerson_t$	=	recurrent health expenditure per person in time t

7.9.7.3.7 Population at high health risk

The population at high health risk is assumed to be the total infant and child population (all persons under the age of 5), plus all females of childbearing age (between 15 and 49). These groups are considered to be highly exposed to certain typical risks associated with their age and sex. For example, children under 5 are more susceptible to disease because of their underdeveloped immune systems and poor nutritional status. Women of reproductive age are at risk because of complications associated with multiple and closely spaced pregnancies, frequently seen in countries with high fertility.

$$HealthRiskPop_t = FemalePop_{15-49,t} + Pop_{0-4,t} \,,$$

where:

$HealthRiskPop_t$ = population considered to be at high risk in time t

$FemalePop_{15-49,t}$ = female population of reproductive age (15-49) in time t

$Pop_{0-4,t}$ = population under the age of 5 in time t

7.9.7.4 Urbanization

As a country develops, it generally makes a transition from being largely rural to having a significant proportion of its population living in urban areas. Urbanization can be particularly rapid in countries that combine a high rate of natural population growth with high rates of rural-to-urban migration. Urbanization does offer some benefits. For example, it creates the critical mass required for airports, seaports, universities, and large factories. If urbanization takes place very rapidly, however, many city dwellers may not have access to such basic needs as clean water, sanitation, and adequate housing. Urbanization rates, wealth, and development policies all interact in complex ways to determine the living conditions of people in urban areas. However, experience has shown that rapid growth of urban populations in developing countries has generally led to significant portions of urban dwellers living in substandard conditions. The RAPID model projects the size of the total urban population and the largest cities under various conditions in order to illustrate the pace and magnitude of the urban growth problem.

7.9.7.4.1 Total urban population

The total urban population is calculated directly through the DemProj module. If no urban projections were made using DemProj, the RAPID display options for the urbanization sector will not appear.

The approach used in DemProj first projects the national population and then distributes it according to region (i.e., urban or rural). It does not make a separate projection for each region. The benefit of this approach is that separate estimates of the total fertility rate (TFR), life expectancy and model life tables are not required. The disadvantage is a lack of flexibility in fully specifying the differences between the regions. If this flexibility is important, then DemProj should be used to project urban and rural regions separately.

There are two methods for developing the urban and rural projections. In the first, the analyst provides an assumption about the percentage of the total population that is urban for each year of the projection. Then rural population is simply the difference between the total and urban populations.

The second approach relies on a method developed and used by the Population Division of the United Nations. This method assumes that the percentage of the entire population that is urban follows an S-shaped curve. Therefore, the rate of urbanization will be slow at first, accelerate when the percent urban reaches 30-70 percent, and then slow down once urbanization reaches high levels. This approach requires an estimate of the annual growth rates of the urban and rural populations in the base year and the size of the urban population by age and sex in the base year. A complete description of the methodology used can be found in the DemProj methodology section, Urban and rural projections.

7.9.7.4.2 Population of major city

The population of the major city is calculated by assuming that the largest city will remain some chosen percentage of the total urban population. This percentage may be modified for each year of the projection to reflect either increased or decreased migration into that particular city. This indicator is useful in illustrating the future urban infrastructure requirements. Also, overall populations in urban

areas (especially in the largest cities) tend to grow more rapidly than in the rural areas, so that related population effects also appear more rapidly. Many audiences will be able to recall clearly and easily when there were many fewer persons living in the largest city, and how the quality of life in the city (e.g., crime rates, unemployment, transportation, water supplies, education, etc.) was much better before the population grew too large.

$$MajorCityPop_t = UrbanPop_t \cdot \%UrbanPopMajorCity_t ,$$

where:

$MajorCityPop_t$ = population living in the major city in time t

$UrbanPop_t$ = total urban population in time t

$\%UrbanPopMajorCity_t$ = percentage of the total urban population living in the major city in time t

7.9.7.4.3 Urban youth (aged 12-25)

The number of urban youth is calculated by summing the number of persons in urban areas between the ages of 12 and 25, inclusive. This indicator is useful in illustrating the number of new employment opportunities, educational opportunities, and housing facilities that will be required in urban areas in the future. It is also an indicator of political and societal stability, as this population has proven to be a destabilizing force when these necessities are absent.

$$UrbanYouth_t = UrbanPop_{12-25,t} ,$$

where:

$UrbanYouth_t$ = the number of urban youth in time t

$UrbanPop_{12-25,t}$ = urban population between the ages of 12 and 25 in time t

7.9.7.5 Agriculture

Agriculture is the key economic sector in many developing countries since it provides a significant proportion of the economy's employment, food, and export earnings. In countries with abundant land and few urban centers, rapid population simply leads to more land under cultivation. However, when land is scarce and a significant proportion of the population lives in cities, then rapid population growth raises the dual problem of less land per capita for food production and more people to feed. Improvements in technology and management can raise yields and lead to increases in the amount of food produced even if the amount of arable land is shrinking. However, it takes time to develop and implement new technologies. Rapid population growth may make it difficult to adopt new technology that will keep up with rising demand for food. In addition, as the intensity of cultivation increases, environmental problems may arise from the clearing of new lands for cultivation, from heavy fertilizer use, and from intensive irrigation. The RAPID model addresses these issues by projecting the amount of arable land per capita in the future and the demand and supply of certain key crops. These indicators are intended to illustrate the pressures created by rapid population growth in the agriculture sector.

7.9.7.5.1 Arable land per capita

The amount of arable land available per capita is projected by dividing the total arable land area by the total population. This indicator is useful in demonstrating how the amount of land supporting each person (or family) will be reduced in the future (i.e., as the population grows and the amount of arable

land remains relatively constant, the parcels of land available to support each person or family will become smaller).

$$ArableLandPerCapita_t = ArableLand_t / TotalPop_t \, ,$$

where:

$ArableLandPerCapita_t$ = amount of arable land available per capita in time t

$ArableLand_t$ = total amount of arable land in time t

$TotalPop_t$ = total population in time t

7.9.7.5.2 Consumption of major crop

The total annual consumption of a country's major crop is projected by multiplying the average annual per capita consumption of that crop by the total population for each year of the projection. This indicator is useful in demonstrating how food production and/or food imports will have to increase in direct proportion to increases in the population. Basic staple crops, such as rice or maize, are usually considered in this analysis.

$$MajorCropCons_t = ConsPerCapita_t \bullet TotalPop_t \, ,$$

where:

$MajorCropCons_t$ = total annual consumption of major crop in time t

$ConsPerCapita_t$ = per capita consumption of major crop in time t

$TotalPop_t$ = total population in time t

7.9.7.5.3 Production of major crop

The total annual production of the country's major crop is projected by multiplying the total production in the previous year by an exogenously specified growth rate. This indicator is especially useful when combined with the annual consumption of the crop to demonstrate the difficulty of food production maintaining pace with population growth. (Note: The production of the major crop in the base year is entered directly into the model.)

$$MajorCropProd_t = MajorCropProd_{t-1} \bullet (1 + ProdGrowth_t) \, ,$$

where:

$MajorCropProd_t$ = total annual production of major crop in in time t, for t > 1

$ProdGrowth_t$ = annual increase in crop production in time t

First-year major crop production (t = 1) is simply the production itself without the multiplier for growth.

7.9.8   Glossary of terms

Some of the following terms were obtained from the Population Reference Bureau's *Population Handbook* (Haupt and Kane, 1989); others were taken from *Economics* (Hyman, 1992).

Annual growth rate in gross domestic product (GDP). The percentage by which the market value of total output produced by a nation changes in a year.

Annual recurrent expenditure. The total amount spent in a year on non-capital items, such as salaries, expendable supplies, and facility maintenance.

Arable land per capita. The land that is fit for cultivation, divided by the total population of a nation.

Average recurrent expenditure. The amount spent per unit of time (usually per year) on recurrent (non-capital) items per beneficiary of the expenditure category. For example, recurrent primary school expenditure per year per primary school student or recurrent maternal and child health (MCH) expenditures per year per child under age 5.

Catchment areas. A geographically defined area from which a service-providing entity (such as a health clinic or hospital) draws the majority of its customers or clients.

Gross domestic product (GDP). The market value of final output produced within the borders of a nation. A measure of income from use of resources within the borders of a nation.

Gross domestic product per capita. The market value of final output produced within the borders of a nation, divided by the total population of that nation. A measure of income from use of resources within the borders of a nation, per each person living there.

Gross national product (GNP). The market value of an economy's final goods and services produced over a period of one year.

Interpolation. Given two numbers that serve as boundary points, it is possible to estimate the values that lie at intervals between the two points. For example, if the total fertility rate for a country or region was actually measured only in 1980 and in 1995, by assuming even increments from year to year, it is possible to interpolate a TFR for each intervening year. (Spectrum uses a linear form of interpolation so that the difference between each annual value is the same. Other nonlinear forms of interpolation also are possible, but are not used in Spectrum.)

Labor force. The total number of persons between the ages of 15 and 64 with jobs in the formal sector and workers who are actively seeking a job in the formal sector but currently do not have one.

Labor force participation rate. The proportion of the total labor force (defined as all able-bodied persons within a defined adult age range) that is economically active in the formal economic sector. Note that farmers in many countries are not considered to be "economically active" in the formal sector either because they are subsistence farmers or because they barter their product outside of the formal sector.

Model. Computer system designed to demonstrate the probable effect of two or more variables that might be brought to bear on an outcome. Such models can reduce the effort required to manipulate these factors and present the results in an accessible format.

Module. Synonym for "model."

Population projection. Computations depicting the future course of a population's size, its structure, and its interaction with dynamics such as fertility, mortality, and migration. The projection is constructed based on assumptions about the future course of those population dynamics.

Pop-up menu. A menu from which users can select items or actions. Pop-up menus can appear anywhere on the screen.

Pull-down menu. A menu opened by clicking on key words at the top edge of the screen. Pull-down menus allow users to select operations.

Radio button. These buttons emulate raised buttons on early radios, which were punched to select radio stations. The graphically portrayed raised "radio buttons" on interfaces permit users to select among alternatives.

Total fertility rate (TFR). The average number of children that would be born alive to a woman (or a group of women) during her lifetime if she were to pass through all her childbearing years conforming to the age-specific fertility rates of a given year.

7.9.9 Acronyms and abbreviations

FAO United Nations Food and Agriculture Organization

GDP gross domestic product

ILO International Labour Organization

IMF International Monetary Fund

RAPI Resources for the Awareness of Population Impacts on Development
D

TFR total fertility rate

UNES United Nations Educational, Scientific, and Cultural Organization
CO

USAI United States Agency for International Development
D

7.9.10 References

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7.10   STI
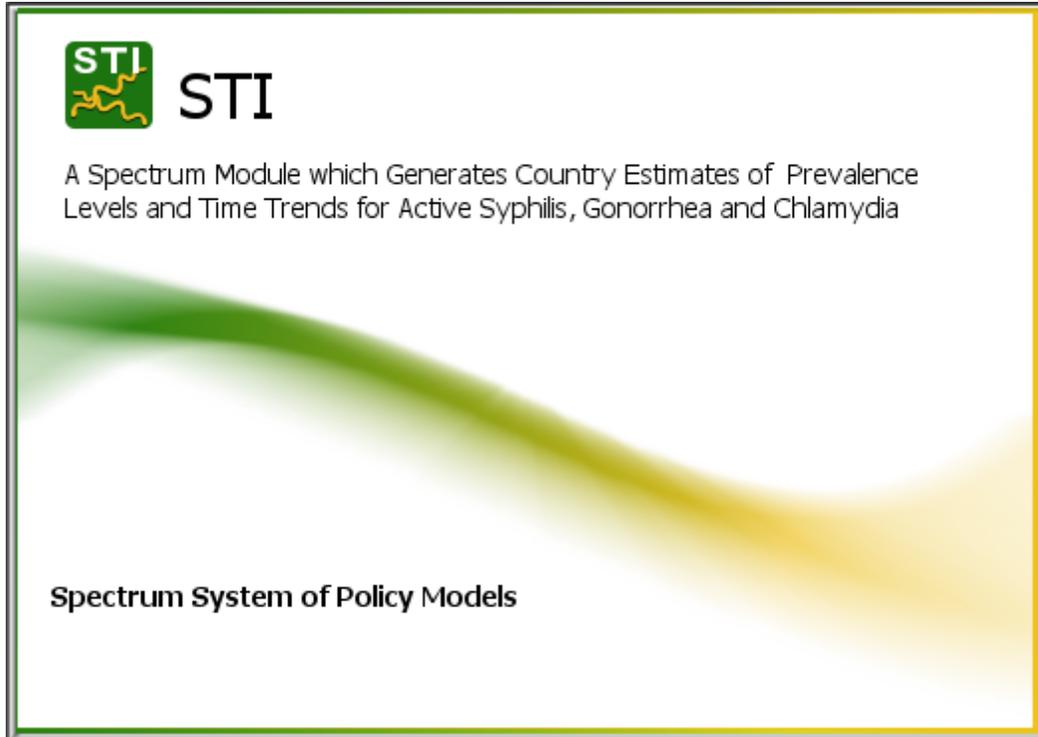
7.10.1 An Overview of the Spectrum STI Module

7.10.1.1 What is STI?

Spectrum-STI is a computer program developed to generate country estimates of prevalence levels and time trends for active syphilis, gonorrhea and chlamydia. Spectrum-STI is a statistical trend fitting model and whilst appropriate for looking at past trends, it should not be used for generating future long term projections.

Spectrum-STI has been developed by Avenir Health with financial support from WHO.

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7.10.1.3 Introduction

Spectrum-STI was designed to look at national trends over time in adults in the prevalence and incidence of sexually transmitted infections. The three STIs currently included in the STI module are *chlamydia*

trachomatis (chlamydia) *Neisseria gonorrhoeae* (gonorrhea) and *Treponema pallidum, subspecies pallidum* (syphilis).

Spectrum-STI generates prevalence and incidence estimates for:

- **Syphilis:** 'probable active' syphilis infection, defined as being concurrently rapid plasma reagin (RPR)-positive and *Treponema pallidum* haemagglutination assay (TPHA)-positive. This is the same definition used by the WHO[1] and the Institute of Health Metrics and Evaluation in their regional and global syphilis estimates.

- **Gonorrhea and chlamydia:** Urogenital infections only. Both infections can also rectal or oropharyngeal infections, but these are not included in Spectrum estimates.

7.10.2 Program tutorial

7.10.2.1 Running Spectrum STI

7.10.2.1.1 Creating a new country STI projection

New estimations or projections can be created in two ways from the Welcome page.
1. Select "New projection" under Getting Started or
2. Select the Home tab and click on" New".

To generate a new estimation users need to:

1. Set the file name and year boundaries for the projection.
- Projection file name This is the name and path for the data files associated with this projection. This name is also used to identify the projection across the Spectrum user interface. The file will take the form of *.PJNZ.
- Boundary Years: Set the first year of the projection to a year before the first known prevalence data point; or if you don't know that yet, to an early historic year. We recommend that you change these to 1990 and 2025. The last year should be set to 2025 – to allow short-term projections of the ongoing and near-future trend.

2. Activate the relevant modules for the projection by clicking on the relevant check boxes. At a minimum you will need to activate 2 modules.
- Demographic Projection (DemProj) under Demographics.
- Sexually Transmitted Infections (STI) under Other health priorities.

In addition, we would recommend that you activate
- AIDS (AIM) under HIV. This module projects the impact of the HIV/ AIDS epidemic. It is optional but recommended especially in countries where HIV is affecting background mortality and age structure.

Do **NOT** activate any other modules.

3. Select a country or global region by clicking the "Default Data" button and selecting a country from the list on the screen and click on the "OK" button. This will take you back to the Projection Manager Screen.

4. Click on the OK button at the bottom of the Projection Manager screen.

Spectrum-STI will now create the projection and load the default demographic, HIV and STI data available for the country. Note, an Internet connection is required for this process. It typically takes up to a minute or two for the data to load. Whilst this is happening the bottom-left corner provides time-changing updates (*Creating demography*, the *Creating AIM* … etc.,) indicating that Spectrum-STI is loading the data. When it is finished processing the program will return to the File management page and the bottom-left corner will say 'Ready'.

> **TIP:**
> Once a projection file has been created, it is not possible to add other Spectrum modules or to change the start or end year. If you have data from before 1990, or anticipate that these will come forward, then set the first boundary year of the projection accordingly. Outputs/Results can easily be adjusted to show fewer years (e.g., the years with actual country data).

7.10.2.1.2 Setting the active projection

You can determine which projection is active, by looking at the top-centre of the Spectrum window. The file name of the active projection will be displayed in the blue bar. If only one projection is open, that is automatically the active projection. To see all projections that are open, look at the bottom-right of the Spectrum window. If more than one projection is open, all of the projection file names are displayed there. The active projection file is the one in bold with a star in front of the name.

> TIPS:
> - If a projection is "active" then any edits made to the STI file (Configuration, STI Data, Biomedical parameters or results) will affect this projection only. They will *not* affect any other projections that are open but are not active.
> - To select another projection to be set as active, use the Set Active button in the menu bar or click on the appropriate file name in the status bar.

7.10.3 Editing the STI Module data

Select Modules from the top Spectrum menu bar in blue and then click on the STI icon to display the STI menu.

There are 5 sub menus. They are described in the following sections: Configuration parameters, Population sizes, STI Data, Biomedical parameters and Results.

7.10.3.1 Biomedical parameters

There are three options under the Biomedical parameter menu: Population patterns; Duration of infection; and Diagnostic test performance

7.10.3.1.1 Population prevalence ratios

The population parameters are used to: (1) standardize and adjust the observed data from prevalence surveys before making a prevalence estimation within a group; (2) generate an estimate for a population group that has no data

There are four types of population parameters.
1. Male-to-female prevalence ratio (see Combining male and female prevalence data)
2. Geographic adjustor or Rural / urban prevalence ratio (see Standardizing prevalence data across studies and Appendix Geography adjustor)
3. Age adjustor (chlamydia only - see Standardizing prevalence data across studies and Appendix Age adjustor)
4. Ratio of prevalence between high-risk groups and low-risk groups (see Standardizing prevalence data across studies)

The values of the population parameters are based on expert opinion, consensus and agreed assumptions used in past global and regional STI estimates, and insights from recent Spectrum-STI country applications. For each population parameter there is a default/best value, as well as a Lower-bound and Upper-bound; the bounds are used to determine the uncertainty in a prevalence estimate that uses the parameter concerned.

The population pattern parameters are all fixed and cannot be changed without going into the Spectrum Developer's mode (for advanced users). To change one or more of these parameters, please contact Eline Korenromp (EKorenromp@avenirhealth.org).

7.10.3.1.2 Duration of infection

The duration of an infection, or STI episode, is defined as the mean length of time that a person carries an infection. This in turn depends on a number of factors including the average duration of infection in the absence of treatment, the probability that a person with symptoms gets treated and how long, on average, it takes for a symptomatic person to get treated. In addition, people who are asymptomatic may receive treatment because of screening programmes, or partner notification, or inadvertent correct therapy while being treated for another health problem. The methods and parameters used to estimate the mean duration of infection are based on the methods used in the WHO 2012 & 2016 global and regional estimates.

All of the parameters that determine the duration of infection (Duration of untreated infection, duration of treated infection, proportion of episodes that is symptomatic and proportion of symptomatic episodes that are treated) can be changed for both men and women and over time to reflect, for example, historic time trends in health care seeking and/or treatment access. The final estimates for duration for each year for women and men are found in the circled columns, in grey font. These cannot be modified (and hence are in grey font); they are calculated from the preceding (left-hand) columns.

More information can be found in Estimating duration of infection.

7.10.3.1.3 Diagnostic test performance

The defaults values of the performance characteristics of each laboratory test type are estimates based on reviews of the literature done for the WHO regional and global estimates and updated and expanded by Avenir Health for use in Spectrum-STI. For more information see Section 7.3 in the Manual. These values are fixed and cannot be adjusted without going into the Spectrum Developer's mode. To change one or more of these parameters please contact Eline Korenromp (EKorenromp@avenirhealth.org).

7.10.3.2 STI Data

There are three options under the STI Data menu: Syphilis; Gonorrhea; and Chlamydia. New projections are initially populated with data from the Spectrum-STI Global Prevalence Database

Most of the data elements, but not all, can be modified, deleted, or added to. The following columns cannot be modified, as they are calculated by the program based on the values (default or user entered) in the other columns.

Syphilis:
- prevalence;
- prevalence, diagnostic test adjusted.

Gonorrhea & Chlamydia:
- prevalence;
- prevalence, diagnostic test adjusted
- urban prevalence test adjusted
- rural prevalence test adjusted
- national prevalence test and geography adjusted

Tip:
- Only data that have a tick in the column "Use data", on the left, will be included in fitting of the model and will be shown in Results prevalence graphs.

To modify data: Select the cell you want to change, make the relevant change and then click on the cell.

To delete prevalence data:
- <u>Temporary:</u> If you don't want to use a data row for a particular estimation, but may want to re-use it later again, uncheck the "Use data" button (first column).
- <u>Permanent:</u> If you want to permanently delete a data row, then use the "delete selected row(s)" button in the bottom row.

To add prevalence data that are not in the Spectrum-STI global database: Click on "Add data". A new line will be introduced at the bottom of the country data file, and the relevant details can be entered.

Prevalence data are entered as the number of people positive and the number tested, not as a percentage. If a study does not provide information on the number of people positive or tested, it is necessary to infer or estimate these based on the reported prevalence.

The column "Weight for Spectrum Fitting in range 0 to 100" is the weight assigned to each study in the statistical trend fitting. Each study is assigned a weight, reflecting its representativeness of the population group being estimated. In the Spectrum-STI global database, these weights were generated by the Spectrum-STI global team. These values, which appear as the default or starting point when a New projection is created in Spectrum-STI, need to be reviewed by users and adjusted to reflect representativeness and quality according to their expert opinion.

The default weights assigned to the **<u>low-risk population data</u>** in the Spectrum-STI global database were generated as follows:

    Syphilis:

- Routine ANC screening data: weight is based on the national coverage of syphilis screening.
- ANC surveys: weight reflects the number of sites sampled or type of survey.
- Surveys in low-risk women (excluding ANC surveys): weight reflects the type of survey
- Surveys in low-risk men: weight reflects the type of survey
- Blood donor data from women: generally assigned a weight of 0.1
- Blood donor data from men: generally assigned a weight of 0.1
- Blood donor data and surveys that did not differentiate between men and women: assigned a weight of 0.

Gonorrhea and Chlamydia:
- Most studies were set at 100%. Some small studies, or studies of a specific age sub-group were assigned a lower weight.

For **FSWs** and **MSM** most studies were set at 100% for all three infections. In some countries when there were data from multiple years and where the number of sites tested varied by year, studies were weighted to reflect this.

The observed prevalence values are converted into true prevalence estimates by adjusting for the sensitivity and specificity of the diagnostic test, the age of the study population (for chlamydia only), and the geographic location of the study population.

Box: Reviewing and updating Spectrum-STI prevalence tables in Excel

Prevalence data tables can be imported into and out of Excel for reviewing and updating.

A. Copying a Spectrum-STI prevalence data table into Excel
- Put the cursor in the middle of the data table, right-click and then select "*Copy all*".
- Switch to Excel, select cell A1 and paste the data.

B. Modifying data in Excel
- Update or correct the relevant cells by typing in new values
  (Note: Do not edit the columns that are calculated by Spectrum-STI – these will be recalculated, and overwritten, by Spectrum-STI when the updated data are copied into Spectrum-STI).

C. Copying data from Excel into a Spectrum-STI prevalence data table
- Check that all of the cells in Excel are formatted as "*General*" (and not: Number, or Custom, etc.).
- Copy the cells starting from the column 'Study year(s)'. Do not try to copy the whole row.
- Switch to Spectrum-STI.
- If the data being input are modifications to an existing data row
  ○ Select the 'Study year(s)' column of the row being changed and paste the copied data.
- If the data are new:
  ○ Select 'Add data' from the Spectrum-STI data table
  ○ Paste the saved data into the newly entered rows at the bottom, starting with the 'Study year(s)'
  ○ Manually select, from the respective drop-down menus, for columns like Use data, sex, population, diagnostic test.
- Confirm your overall changes to the data editor by clicking 'OK'.
- Save the updated projection file, under File, 'Save' or 'Save as'.

7.10.3.2.1 Standardizing prevalence data

7.10.3.2.1.1 Diagnostic test performance

The defaults values of the performance characteristics of each laboratory test type are estimates based on reviews of the literature done for the WHO regional and global estimates and updated and expanded by Avenir Health for use in Spectrum-STI. These values are fixed and cannot be adjusted without going into the Spectrum Developer's mode. To change one or more of these parameters please contact Eline Korenromp (EKorenromp@avenirhealth.org).

The default laboratory test adjustors for syphilis are based on two global meta-analyses of prevalence ratios in consultation with international STI experts. They were assumed to remain constant over time.

Laboratory test adjustor for syphilis – default values

Testing regime	Adjustor
RPR & TPHA	1.0
TPHA only	0.53
RPR only	0.60
Rapid TPHA-based test	0.70
Unknown test	0.75

References

Ham DC, Lin C, Newman L, Wijesooriya NS, Kamb M. Improving global estimates of syphilis in pregnancy by diagnostic test type: A systematic review and meta-analysis. Int J Gynaecol Obstet. 2015;130 Suppl 1:S10-4. Epub 2015/05/13. doi: 10.1016/j.ijgo.2015.04.012. PubMed PMID: 25963909.

Smolak A, Rowley J, Nagelkerke N, Kassebaum N, Chico RM, Korenromp EL, et al. Trends and predictors of syphilis prevalence in the general population: Global pooled analyses of 1103 prevalence measures including 136 million syphilis tests. Clin Infect Dis. 2017;Nov 9. doi: 10.1093/cid/cix975

The methods for standardizing data from prevalence studies were based on the methods and parameter values used to generate the WHO 2016 estimates. A standardized prevalence data point was obtained by adjusting the reported prevalence to reflect the sensitivity and specificity of the diagnostic test used, the age of the study population, and the geographic location of the study population using the following formulas:

$$SP = \frac{(RP + Specificity - 1)}{(Sensitivity + Specificity - 1)} \times age\ adjustor \times geography\ adjustor$$

where SP is the standardized prevalence, RP is the reported prevalence, specificity is the reported specificity of the lab test and sensitivity is the reported sensitivity of the lab test.

When a negative number is generated for the standardized prevalence Spectrum-STI resets the standardized prevalence at 1 case divided by 100 times the sample size.

The sensitivity and specificity of the different diagnostic tests were based on a WHO supported review for the global and regional STI estimates.

7.10.3.2.1.2 Age adjustor

Prevalence data for chlamydia in women and men were systematically adjusted for age. No adjustments were made for gonorrhea in women or men. The default values were assumed to remain constant over time.

Age adjustors

Sex	Age Group (years)	Value	Lower-bound	Upper-bound	Reference
Chlamydia					
Women	15-24	0.59	0.44	0.74	Kularatne et al. 2018
	25-49	1.39	1.04	1.74	Kularatne et al. 2018
	15-49	1.0	1.0	1.0	Reference category
	Unknown	1.0	1.0	1.0	Reference category
Men	15-24	0.8	0.60	1.00	Avenir Health (average between no adjustment in WHO global estimates, and strong adjustment for South Africa [Kularatne et al 2018]
	25-49	1.2	1.00	1.50	
	15-49	1.0	1.0	1.0	Reference category
	Unknown	1.0	1.0	1.0	Reference category
Gonorrhea					
Women	All age groups	1.0	0.75	1.25	WHO 2012 & 2016 global & regional estimates
Men	All age groups	1.0	0.75	1.25	WHO 2012 & 2016 global & regional estimates

References:

Kularatne R, Niit R, Rowley J, Kufa T, Peters RPH, Taylor M, et al. Adult gonorrhea, chlamydia and syphilis prevalence, incidence, treatment and syndromic case reporting in South Africa: estimates using the Spectrum-STI model, 1990-2017. PLoS ONE. 2018;i 13(10): e0205863.

Newman L, Rowley J, VanderHoorn S, Wijesooriya NS, Unemo M, Stevens G, et al. Global estimates of the prevalence and incidence of four curable sexually transmitted infections in 2012 based on systematic

review and global reporting. PLoS One. 2015;10(12):e0143304. Epub Dec 8. doi: 10.1371/journal.pone.0143304.

Rowley JTF, Van der Hoorn S, Korenromp E, Taylor M, et al. Global Estimates of the Prevalence and Incidence of Four Curable Sexually Transmitted Infections in 2016. Bull World Health Organ 2019;97:548–562. doi: http://dx.doi.org/10.2471/BLT.18.228486.

7.10.3.2.1.3 Geography adjustor

The geography adjustor reflects both the proportion of the population living in urban areas and the ratio of the prevalence of infection in rural areas to urban areas (assumed to be 0.9).

Data from studies where information was available for both rural and urban areas suggest that the prevalence of non-ulcerative STIs is generally higher in urban areas than in rural areas. The number of studies with both urban and rural data for syphilis, chlamydia or gonorrhea, however, was small.

Spectrum-STI uses the urban-to-rural prevalence ratios to calculate for each study an urban prevalence, a rural prevalence and a corresponding 'urban + rural' prevalence. To calculate the latter, the country and group's urban and rural prevalences are aggregated, weighted by the country's national urban and rural population sizes, for the study year, using UN Population Division population estimates contained in the Spectrum DemProj module. No adjustment was made for studies that involved samples from different types of sites or where it was not clearly stated.

Geography adjustors

Type of population	Adjustor
National	1
Urban	0.947
Rural	1.052
Unknown	1

7.10.3.2.2 Estimating Prevalence

7.10.3.2.2.1 Standardizing prevalence data across studies

The studies that met the study entry criteria used a variety of laboratory tests and were from different populations. To improve the consistency of data across these studies the observed prevalence values were converted into true prevalence estimates by adjusting for the sensitivity and specificity of the diagnostic test used and also the age of the study population (for chlamydia only) and the geographic location of the study population.

The method used for standardizing data from prevalence studies is based on the methods used in the WHO global and regional estimates.

SP = OP x diagnostic test adjustor x age adjustor x geography adjustor

Where SP is standardized prevalence and OP the observed prevalence

If a study reported a prevalence of 0 (ie. OP was 0) this value was replaced by a prevalence calculated as 1 case divided by 100 times the sample size, to allow for logistic regression and generation of uncertainty intervals. In addition, if a negative number was generated for the standardized prevalence the standardized prevalence it was reset at 1 case divided by 100 times the sample size.

References

Newman L, Rowley J, VanderHoorn S, Wijesooriya NS, Unemo M, Stevens G, et al. Global estimates of the prevalence and incidence of four curable sexually transmitted infections in 2012 based on systematic review and global reporting. PLoS One. 2015;10(12):e0143304. Epub Dec 8. doi: 10.1371/journal.pone.0143304.

Rowley JTF, Van der Hoorn S, Korenromp E, Taylor M, et al. Global Estimates of the Prevalence and Incidence of Four Curable Sexually Transmitted Infections in 2016. Bull World Health Organ 2019;97:548–562. doi: http://dx.doi.org/10.2471/BLT.18.228486.

7.10.3.2.2.2 Weighting data from different studies

Each study is assigned a weight, reflecting its representativeness of the population group being estimated. In the Spectrum-STI global database, these weights were generated by the Spectrum-STI global team. These values, which appear as the default or starting point when a New projection is created in Spectrum-STI, need to be reviewed by users and adjusted to reflect representativeness and quality according to their expert opinion.

The default weights assigned to the **low-risk population data** in the Spectrum-STI global database were generated as follows:

Syphilis:
- Routine ANC screening data: weight is based on the national coverage of syphilis screening.
- ANC surveys: weight reflects the number of sites sampled or type of survey.
- Surveys in low-risk women (excluding ANC surveys): weight reflects the type of survey
- Surveys in low-risk men: weight reflects the type of survey
- Blood donor data from women: generally assigned a weight of 0.1
- Blood donor data from men: generally assigned a weight of 0.1
- Blood donor data and surveys that did not differentiate between men and women: assigned a weight of 0.

Gonorrhea and Chlamydia:
- Most studies were set at 100%. Some small studies, or studies of a specific age sub-group were assigned a lower weight.

For **FSWs** and **MSM** most studies were set at 100% for all three infections. In some countries when there were data from multiple years and where the number of sites tested varied by year, studies were weighted to reflect this.

7.10.3.2.3 Estimating prevalence over time

7.10.3.2.3.1 Combining male and female prevalence data

The table below summarizes how the prevalence data are pooled to generate the trend estimates for low-risk women, FSW, low-risk men, and MSM. Once the prevalence trend estimation is done for each

group, Spectrum-STI aggregates the groups into a national estimate by weighting the prevalence in each population group by its population size. The uncertainty distributions (95% Cis) for the national estimates are calculated by combining the respective variances as if they were independent.

Approaches used to generate estimates.

	Syphilis:	**Gonorrhea and chlamydia:**
Low-risk women	Estimated by pooling data from low-risk population groups (e.g., ANC survey, ANC routine screening, surveys in low-risk women, blood donors). Prevalence data can also be included that does not disaggregate between women and men (e.g. routine blood donor screening results, or general population surveys). If there are no data from low-risk women, but an estimate was generated for low-risk men, then the prevalence in low-risk women is estimated from the low-risk men's prevalence, using the male-to-female prevalence ratio. If there are no data from low-risk women or men but there is an estimate for FSWs or another female high-risk group, then the high-risk to low-risk ratio is used. Otherwise no estimate generated.	Estimated by pooling prevalence data from low-risk women (e.g., ANC, pregnant women in the community/outside ANC, clinic attendees, Ob/Gyn clinic attendees, community, military, students, young, workers, blood donors, and mixed groups). If there are no data for low-risk women, but there is an estimate for FSW or another female high-risk group, then high-risk to low-risk female ratio is used. Otherwise no estimate generated.
FSW	Estimated from FSW prevalence data If there are no FSW prevalence data but there is a low-risk estimate for women, then the FSW prevalence is generated from the low-risk estimate using the high-risk to low-risk prevalence ratio for women. Otherwise no estimate generated.	Estimated from FSW prevalence data. If there are no FSW prevalence data but there is a low-risk estimate for women, then the FSW prevalence is generated from the low-risk estimate using the high-risk to low-risk prevalence ratio for women. Otherwise no estimate generated.
Low-risk men	Estimated by pooling data from low-risk men (e.g., clinic attendees, community, military recruits, students, young, workers, blood donors). If there are no data or the available data are not active (Use data = N or Spectrum-STI Weight set at 0) then the prevalence in low risk men is estimated from the prevalence in low-risk women	Estimated by pooling prevalence data from low-risk men. If there are no data or the available data are not active (Use data = N or Spectrum-STI Weight set at 0) then the prevalence in low risk men is estimated from the prevalence in low-risk women using the male-to-female prevalence ratio. If there is no low risk female or low-risk male data but there is data and an estimate for MSM

	Syphilis:	**Gonorrhea and chlamydia:**
	using the male-to-female prevalence ratio. If there is no low risk female or low-risk male data but there is data and an estimate for MSM or, if no MSM data, another male key group, then the high-risk to low-risk ratio used. Otherwise no estimate generated.	or, if no MSM data, another male key group, then the high-risk to low-risk ratio used. Otherwise no estimate generated
MSM	Estimated by pooling MSM prevalence data. If there are no MSM prevalence data but there is a low-risk estimate for men, then the MSM prevalence is generated from the low-risk estimate using the high-risk to low-risk prevalence ratio for men. Otherwise no estimate generated.	Estimated by pooling MSM prevalence data. If there are no MSM prevalence data but there is a low-risk estimate for men, then the MSM prevalence is generated from the low-risk estimate using the high-risk to low-risk prevalence ratio for men. Otherwise no estimate generated.

When there are insufficient data for a region to generate an estimate for a particular population or infection Spectrum-STI is structured to estimate prevalence using male-to- female ratios) or high-risk to low-risk prevalence ratios. These ratios are based on the estimates used in the WHO 2012 and 2016 Global Estimates and expert discussions.

Male-to-Female prevalence ratio. Ratios are assumed to be time constant.

	Value	**Lower-bound**	**Upper-bound**
Syphilis	1.0	0.667	1.33
Gonorrhea	0.86	0.53	1.07
Chlamydia	0.80	0.60	1.00

High-risk group to low-risk group prevalence ratio. Ratios are assumed to be time constant.

STI	Population group	Sex	Value	Lower-bound	Upper-bound
Syphilis	FSW	Women	10.0	7.5	15.0
	OtherHighRisk-Women	Women	10.0	5.0	20.0
	MSM	Men	10.0	7.5	15.0
	OtherHighRisk-Men	Men	10.0	5.0	20.0

STI	Population group	Sex	Value	Lower-bound	Upper-bound
Gonorrhea	FSW	Women	10.0	7.5	15.0
	OtherHighRisk-Women	Women	10.0	5.0	20.0
	MSM	Men	10.0	7.5	15.0
	OtherHighRisk-Men	Men	10.0	5.0	20.0
Chlamydia	FSW	Women	5.0	3.8	7.5
	OtherHighRisk-Women	Women	5.0	1.5	6.0
	MSM	Men	10.0	7.5	15.0
	OtherHighRisk-Men	Men	10.0	5.0	20.0

References:

Newman L, Rowley J, VanderHoorn S, Wijesooriya NS, Unemo M, Stevens G, et al. Global estimates of the prevalence and incidence of four curable sexually transmitted infections in 2012 based on systematic review and global reporting. PLoS One. 2015;10(12):e0143304. Epub Dec 8. doi: 10.1371/journal.pone.0143304.

Rowley JTF, Van der Hoorn S, Korenromp E, Taylor M, et al. Global Estimates of the Prevalence and Incidence of Four Curable Sexually Transmitted Infections in 2016. Bull World Health Organ 2019;97:548–562. doi: http://dx.doi.org/10.2471/BLT.18.228486.

7.10.3.2.3.2 Syphilis

Spectrum-STI provides two alternative statistical estimation methods to fit the available syphilis data in a population group over time:
- Logistic regression;
- Segmented polynomials for incidence.

Logistic regression is the default method set for syphilis for all groups when a new Spectrum-STI projection file is created. This method is much quicker to run than the segmented polynomial regression, but will always give a monotonous increase or decrease in prevalence throughout the time period estimated. This approach should be used for initial test runs, data editing and quality checking.

In the segmented polynomial (spline) for incidence approach, prevalence is fitted through the underlying infection incidence. This allows for flexible time trends, including smooth reversals in prevalence, and year-on-year fluctuations in prevalence are constrained as incidence cannot drop below zero. In Spectrum-STI the spline is restricted to having at most 2 knots, which means that there can be at most three epidemic phases over the projection horizon. When there are fewer than 3 data points, the spline produces results similar to logistic regression: the slope is dropped in the estimation and only a constant intercept is estimated, producing a time-constant estimate in case of only 1 data point, and a monotonous rise or decline in case of 2 data points.

For both statistical methods, the data are scaled by dividing by sample size, so that the sample size does not influence the estimated prevalence level or trend but does influence confidence bounds. The 95% confidence intervals (CI) for prevalence are then derived by bootstrapping, and the median of the bootstrapped prevalence is the final estimate.

In addition, Spectrum-STI extrapolates syphilis trend estimates in a population to a user specified length of time before the first prevalence data point and after the last data point. Before and after these dates, prevalence is assumed to be constant.

For more information see Technical Annex 2 of the User Guide to the Spectrum-STI Module available from Avenir Health (https://spectrummodel.zendesk.com/hc/en-us/articles/115001964191-Spectrum-STI-Module-Overview-Manual)

References

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Korenromp EL, Mahiané SG, Nagelkerke N, Taylor M, Williams R, Chico RM, et al. Syphilis prevalence trends in adult women in 132 countries – estimations using the Spectrum Sexually Transmitted Infections model. Scientific Reports. 2018;8(1). Epub Jul 31. doi: 10.1038/s41598-018-29805-9.

7.10.3.2.3.3 Gonorrhea and Chlamydia

Gonorrhea and chlamydia prevalence in each population group are estimated over time as a moving average through the standardized and weighted prevalence data. Prior to doing the estimation, each prevalence data point is divided by sample size so that sample size does not influence the estimated prevalence level or trend but does influence the confidence bounds. When generating the moving average, the relative contribution of each data point to the estimate for a particular year reflects how close it is to the year being estimated. Each year further away results in its contribution falling by a fixed percentage (called the annual dilution factor), which is set at 20% as default.

This estimation method is applied throughout the period with any data available; for years before the first data point and after the last data point, the estimate is flat-lined at the value of that earliest year with data and latest year with data, respectively.

95% confidence intervals (CI) are derived by bootstrapping, combining uncertainties in each survey's observed prevalence, and in the male-to-female prevalence ratio, urban-to-rural prevalence ratio, and high-risk to low-risk population prevalence ratio.

For more information see the Appendix - Statistical Methods - Prevalence.

7.10.3.2.4 Spectrum STI database

7.10.3.2.4.1 Prevalence data

The Spectrum-STI global database has been populated with prevalence data from 1980 to 2018. The data included in the database come from studies using an internationally recognised diagnostic test (see Diagnostic test performance) with adequate performance characteristics on urine, urethral, serum or cervico-vaginal specimens conducted among:

- Populations considered representative of the general adult population. This includes: pregnant women, women at delivery, women attending family planning clinics, adults in household surveys, and military recruits;

- Men who have sex with men (MSM);
- Commercial female sex workers (FSW);
- In addition, for syphilis for countries with very few data points from populations considered representative of the general adult population routine national blood donor screening were included [1].

The data in the database come from a variety of sources including:

- WHO STI database of general population prevalence surveys in low-risk adult men and/or women compiled for the 2005, 2008, 2012 and 2016 global and regional STI estimates [2-4];
- Syphilis prevalence data reported to the Global AIDS Monitoring (GAM) system [5]. Prevalence data for ANC women are based on the GAM data set as of December 2017 and include data from sentinel surveys in pregnant women attending ANC care and routine programmatic screening in ANC. The data for MSM and FSW are based on the GAM data set as of August 2018 and are from surveys.
- WHO global status report on blood safety and availability which includes national blood donor screening results for syphilis [6];
- Institute of Health Metrics and Evaluation (IHME) syphilis prevalence database compiled for the 2015 Global Burden of Disease study [7];
- Systematic reviews of
  - o STI prevalence among pregnant women in antenatal care in sub-Saharan Africa [8]
  - o Curable STIs in pregnant women of low- and middle-income countries [Williams, in prep]
  - o Gonorrhea prevalence in the Middle East and North Africa [Smolak, in prep]
  - o Chlamydia prevalence in the Middle East and North Africa [9]
- Data compiled by the 10 countries that have used Spectrum-STI to generate national estimates as of September 2018 (Zimbabwe [10], Morocco [11, 12], Mongolia [13, 14], Colombia [15], Georgia [16], South Africa [17], China [18], Papua New Guinea, Fiji, Samoa and The Federal States of Micronesia [19]);
- Other data brought to the attention of the Avenir Health team (e.g., national HIV/syphilis household surveys conducted in 2016-2018 in Zimbabwe, Uganda and other African countries with support of the USA CDC and PEPFAR [20]).

The codes used in the database for the different population groups are summarized in Table A1.1

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7.10.3.2.4.2 Other data: syphilis

For syphilis the database also includes information from country reports of routine, continuous ANC screening results, from health ministries into GAM, for the indicators:

- Coverage of routine syphilis screening among women presenting for first ANC visit (or, if first visit not available, any ANC visit), among pregnant women attending for first ANC visit;

- The number of women screened for syphilis at first ANC visit (the denominator of the preceding indicator);

- Prevalence of syphilis among women screened at first ANC visit (or if first visit not available, any ANC visit).

7.10.3.3 Configuration parameters overview

7.10.3.3.1 Configuration parameters

All of the parameters can be changed. However, we recommend that you do not change any of these parameters. The default values reflect best-practice, global values as proposed by Avenir Health, WHO and specialist advisors. The source box provides a list of related references. If you do make any changes, you will need to click on the "Ok" box to save them.
.
Adjustment for zero prevalence: If a study reported a prevalence of 0 this value is replaced by the "adjustment for zero prevalence" multiplied with the sample size, so as to allow for logistic regression and generation of uncertainty intervals.
Number of bootstraps: The default value is set to 400. Simulations suggest that this number typically is enough to obtain a good approximation of both incidence and prevalence over time, using their respective medians. For the final estimates, (i.e. after the data sets have been finalized and weights assigned), the number of bootstraps can be increased to 1,000, in order to smooth the curves.

7.10.3.3.2 Configuration parameters Syphilis

All of the parameters can be changed. However, we recommend that you do not change any of these parameters. The default values reflect best-practice, global values as proposed by Avenir Health, WHO and specialist advisors. The source box provides a list of related references. If you do make any changes, you will need to click on the "Ok" box to save them.

Maximum prevalence by population: The estimated point prevalence and the upper bound of the 95% CI for each population group are restricted. The default maximum values are based on empirical data from across low- and middle-income countries since 1990.

Extrapolation period: Users can specify how long before and after the first and last data point, respectively, Spectrum-STI extrapolates the time trend estimation. Before and after these dates, prevalence is assumed to be constant.

Syphilis Fitting type by population: Spectrum-STI provides two alternative statistical estimation methods to fit the available syphilis data in a population group over time:
- Logistic regression;
- Segmented polynomials for incidence.

Logistic regression is the default method set for syphilis for all groups, when a new Spectrum-STI projection file is created. This method is much quicker to run than the segmented polynomial regression, but will always give a monotonous increase or decrease in prevalence throughout the time period estimated. This approach should be used for initial test runs, data editing and quality checking.

In the segmented polynomial (spline) for incidence approach, prevalence is fitted through the underlying infection incidence. This allows for flexible time trends, including smooth reversals in prevalence, and year-on-year fluctuations in prevalence are constrained as incidence cannot drop below zero. In Spectrum-STI the spline is restricted to having at most 2 knots, which means that there can be up to three epidemic phases over the projection horizon.

For both statistical methods, the data are scaled by dividing by sample size, so that the sample size does not influence the estimated prevalence level or trend but does influence confidence bounds. The 95% confidence intervals (CI) for prevalence are then derived by bootstrapping, and the median of the bootstrapped prevalence is the final estimate.

At bottom of this Configuration window, users can specify if they want to include prevalence data points that were not disaggregated by sex in the low-risk female and/or the low-risk male syphilis estimations. If (either or both of) the boxes are checked, then data from studies that present data for males and females combined (M + F) are included in the (female and/or male) estimates.

7.10.3.3.3 Configuration parameters Gonorrhea

All of the parameters can be changed. However, we recommend that you do not change any of these parameters. The default values reflect best-practice, global values as proposed by Avenir Health, WHO and specialist advisors. The source box provides a list of related references. If you do make any changes, you will need to click on the "Ok" box to save them.

Gonorrhea and chlamydia prevalence in each population group are estimated as a moving average through the standardized and weighted prevalence data. Prevalence data points are divided by sample size, so that sample size does not influence the estimated prevalence level or trend but does influence the confidence bounds. The relative contribution of each data point to the estimate for a particular year reflects how close it is to the year being estimated. Each year further away results in its contribution falling by a fixed percentage (the annual dilution factor).

7.10.3.3.4 Configuration parameters Chlamydia

All of the parameters can be changed. However, we recommend that you do not change any of these parameters. The default values reflect best-practice, global values as proposed by Avenir Health, WHO

and specialist advisors. The source box provides a list of related references. If you do make any changes, you will need to click on the "Ok" box to save them.

Gonorrhea and chlamydia prevalence in each population group are estimated as a moving average through the standardized and weighted prevalence data. Prevalence data points are divided by sample size, so that sample size does not influence the estimated prevalence level or trend but does influence the confidence bounds. The relative contribution of each data point to the estimate for a particular year reflects how close it is to the year being estimated. Each year further away results in its contribution falling by a fixed percentage (the annual dilution factor).

7.10.3.4 Population sizes

The Spectrum-STI input data file includes national estimates and projections by year for each country (UN Population Division, World Population Prospects 2017) of women and men 15 to 49 years of age and estimates of the number of FSW and MSM.

Spectrum-STI input data file includes national estimates and projections by year for each country of
- Total population, women 15-49 years
- Total population, men 15-49 years

These were drawn from the UN Population Division, World Population Prospects 2017 version.

Low-risk women and men
The number of low-risk adult women and men are generated by the program by subtracting the size of all the key groups (i.e., FSW, MSM) from the total population of women and men. The low-risk population estimates cannot be changed manually.

Female sex workers and Men who have sex with men
The Spectrum-STI input data file includes population size estimates for FSW and MSM based on:
1. Data reported by countries into the GAM system until May 2018. The GAM estimates are based on Integrated Bio-Behavioural Survey (IBBS) or other national Population Size Estimation studies.
2. For countries that did not report size estimates to GAM estimates were based on the estimates used in the country's HIV epidemic estimation, when available, i.e. based on values used in their national (UNAIDS-supported) calibration to the Asian Epidemic Model or the Spectrum's AIM/EPP model.
3. When no national size estimates were available regional estimates were based on a literature review conducted by UNAIDS, GFATM and WH (see Table).

All of these population sizes can be modified. As size estimates for FSW and MSM are typically only available for a subset of years for any country, Spectrum-STI assumes that FSW and MSM are a fixed proportion of the total adult (15-49 years) population for those years without data. For example, if a country has 4,000 FSW in a population of 4 million women 15 to 49 years of age in 2012 then the FSW population is set at 1%, for all years throughout 2000-2025.

Estimates of the population proportions of key populations in UNAIDS regions

% of 15-49 year-old women or men who are:	FSW	MSM
Asia and Pacific	0.35%	1.69%
Caribbean	0.49%	2.71%
Latin America	0.49%	1.49%
East and Southern Africa	0.58%	1.28%

East Europe and Central Asia	0.68%	1.39%
Western and Central Europe and North America	0.58%	1.28%
North Africa and Middle East	1.18%	0.90%
West and Central Africa	1.19%	0.72%

Adding new populations

Spectrum-STI can be used to generate estimates for other population groups (e.g., PWID, or prisoners). In order to generate these estimates population size estimates will need to be entered for each new population. This is done by using the "Add female population" or "Add male population" buttons at the bottom of the STI Data page.

References

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7.10.3.5 Results

Users need to specify the desired configuration of the STI estimation output:
1. Sex: whether they want to view the results for males and females combined, males only or females only.
2. Display interval: single years or every five or ten years
3. Chart type: line graph or table
4. Time period: First and Final year of results shown.

For prevalence estimates users can select to view, for one or more sub-populations in females, males, or females + males combined: the Spectrum-STI trend (median) estimate with the corresponding 95% confidence interval, the statistical line of best fit and/ or the (test-adjusted) prevalence data points that informed the statistical fit.
The incidence rate and number of incident cases results take the same format as the prevalence results. The only difference is that the incidence graphs to do not have the option of showing data points (since all data were prevalence).

Tips:
- Prevalence graphs tend to get overcrowded if "Show confidence intervals" and "Show data points" are both selected. We recommend selecting one or the other.
- The Median estimate is the most appropriate estimate to use when presenting Spectrum-STI results, because it is the median within the presented 95% confidence interval.

Box: Exporting Spectrum-STI results into Excel

All of the Spectrum-STI result tables and line graphs can be exported into Excel, and then turned into additional charts using the various Excel features (see https://www.excel-easy.com/data-analysis/charts.html).

To export the results:
1. Put the mouse somewhere in the middle of one of the results tables or graphs and then right-click *Copy all* if a table or right click *Copy chart (Image)* to copy the graph or *Copy chart (data)* to copy the date in the figure.
2. Paste the Spectrum output table into Excel.

7.10.4 Appendices

7.10.4.1 Estimating duration of infection

The duration of an infection, or STI episode, is defined as the mean length of time that a person carries an infection. This in turn depends on a number of factors including the average duration of infection in the absence of treatment, the probability that a person with symptoms gets treated and how long, on average, it takes for a symptomatic person to get treated. In addition, people who are asymptomatic may receive treatment because of screening programmes, or partner notification, or inadvertent correct therapy while being treated for another health problem. The methods and parameters used to estimate the mean duration of infection are based on the methods used in the WHO 2012 & 2016 global and regional estimates.

References

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7.10.4.1.1 Access to treatment

Treatment patterns vary widely between countries and within countries, and this situation depends on access to healthcare as well as cultural and economic factors. To adjust for these factors countries were placed into one of 10 regions and each region was assigned one of three treatment groups. Spectrum by default uses the regional and treatment group allocation used in the 2012 WHO global and regional estimates. It is, however, possible to change a country's treatment coverage, and the assumed duration of untreated and treated infection, to reflect country data and to have these change over time to reflect, for example, improvements in clinical STI management access and/or quality.

Allocation of regions into one of three treatment groups according to probability of treatment

Treatment group	Regions
A	- Australasia and High Income Asia Pacific - High income North America - Western Europe

B	• Andean, Central, Southern, Tropical Latin America & Caribbean • North Africa & Middle East • Oceania • East Asia • Central & Eastern Europe & Central Asia
C	• Central, Eastern & Western Sub-Saharan Africa • Southern Sub-Saharan Africa • South Asia & South East Asia

7.10.4.1.2 Gonorrhea and Chlamydia

For gonorrhoea and chlamydia, the duration of infection (D) for a person of sex (k) in treatment area (r) was estimated using the following equation:

$$D(k,r) = S(k,r) \times [V_S(k,r) T_S(k,r) + (1 - V_S(k,r)) U_S(k,r)]$$
$$+ (1 - S(k,r))$$
$$V_A(k,r) T_A(k,r) + (1 - V_A(k,r)) U_A(k,r)]$$

where:

$S(k,r)$ was the probability that an infected person is symptomatic (S).

$V_S(k,r)$ and $V_A(k,r)$ was the probabilities that infected people who were symptomatic $S(\ )$ and asymptomatic $A(\ )$ were treated, respectively.

$T_S(k,r)$ and $U_S(k,r)$ was the average durations of infections for symptomatic $S(\ )$ people who were treated $T(\ )$ and not treated $U(\ )$, respectively.

$T_A(k,r)$ and $U_A(k,r)$ was the average durations of infections for asymptomatic (A) people who were treated and not treated, respectively.

The estimates are based on the assumptions below

Probability of men and women developing symptoms

Infection	Men	Women
Chlamydia	0.54	0.17
Gonorrhea	0.64	0.34

Average duration of infection

Infection	Asymptomatic and not treated		Symptomatic and treated	
	Men	Women	Men	Women
Chlamydia	15 months	15 months	4 weeks	8 weeks
Gonorrhea	5 months	6 months	2 weeks	4 weeks

Probability that a symptomatic person is adequately treated, by treatment access group[†]

Treatment access group	Probability in men	Probability in women
A – good access	0.80	0.75

B – moderate access	0.65	0.50
C – poor access	0.35	0.225

†*The probability that an asymptomatic person is treated is assumed to be 10% of the probability that a symptomatic person is treated.*

7.10.4.1.3 Syphilis

A similar approach was followed for syphilis, after adjusting for the different stages of infection (primary, secondary, and latent). The probability of adequate treatment was assumed to be the same for men and women. It was also assumed that people with primary and secondary syphilis who did not develop symptoms were not treated.

The estimates are based on the assumptions below. For all of the parameters it is assumed that there was no difference between men and women.

Probability of developing symptoms by stage of infection.

% of episodes symptomatic	Primary stage	40%
	Secondary stage	60%

Probability that a person is adequately treated for syphilis according to treatment group

Treatment group	Symptomatic primary and secondary stages	Latent stages
A– good access	0.85	0.95
B– moderate access	0.60	0.85
C– poor access	0.35	0.75

Average duration of infection in a person with syphilis, depending on stage at which they are treated

Stage of infection	time
Primary	1 month
Secondary	3 months
Latent	3 years
Tertiary	15 years

8 Tools

8.1 Extract

The extract feature enables you to extract the projected data from a previous projection (or multiple previous projections) on one or more indicators. The extracted data is then saved to a CSV file, and can be imported into excel for further analysis. An example would be to use the extract feature to extract the data for "Sex ratio" for both Projection1 and Projection2 into an excel table all at once.

After entering OneHealth, go to "Tools" and click on the "Extract" icon. (Note: this command is not available if you have any projections open. If the command is not available, first click the round application button in the upper left corner of the screen and select "Close projection". If more than one projection is open the "Select projection" window will open. To close all projections select "All projections".) The Extract window will appear as follows:
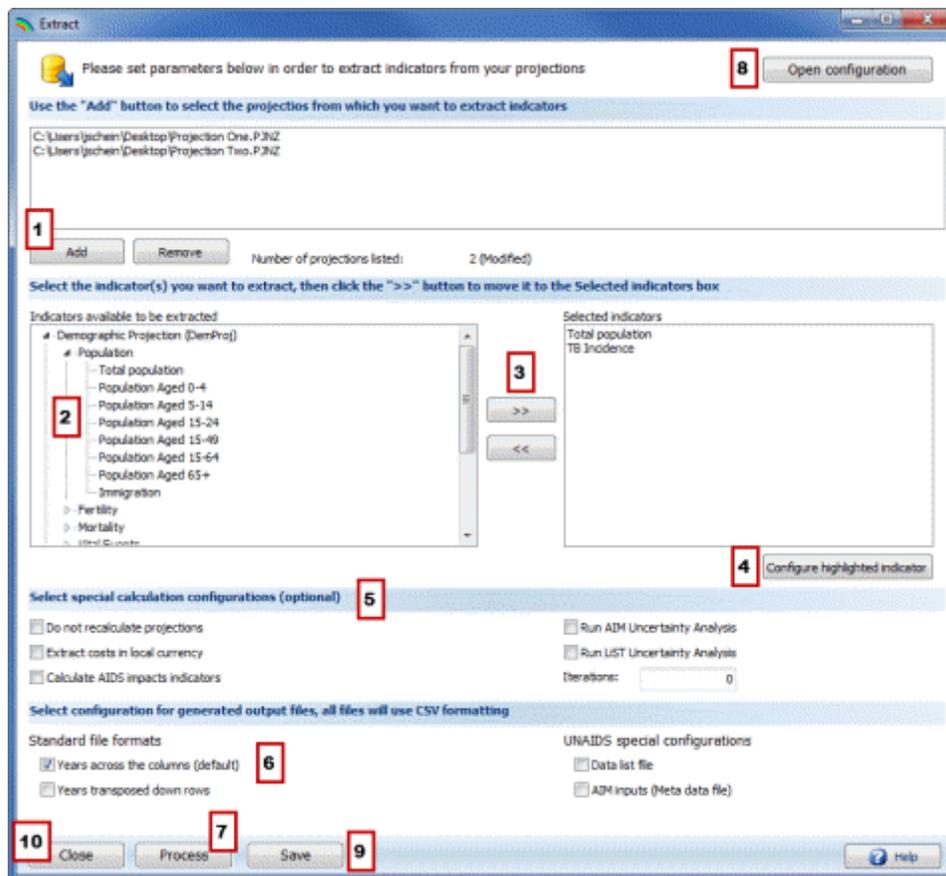
1. Click "Add" to browse and add a previously saved projection to the selected projections box. You can select as many files as you want. Highlight a projection from the selected projections box and click "Remove" to remove it.

2. Once a projection(s) is added to the selected projections box, the indicators for that projection will appear in the "Indicators available to be extracted" box. Click on the small arrows to the left of the categories to open the categories and see the indicators housed within them.

3. To pull an indicator into the box of "Selected Indicators" that you wish to work with, highlight the indicator in the "Indicators available to be extracted" box and click the ">>" button. To remove an indicator from the "Selected Indicators" box, highlight it and click "<<".

4. To further refine your selected indicator by sex or region (urban/rural), highlight the indicator in the "Selected Indicators" box and click "Configure highlighted indicator".

5. Select any special calculation configurations that you would like to use.

6. Select the output file configuration you would like to use. All files will be saved with CSV formatting.

7. To process the extraction, click the "Process" button. Enter the file name you wish to save the extraction as, and click "Ok". It will then be saved as a CSV file, ready for use in Excel.

8. If you have a previous "Extract" configuration saved as an .ex file, you may open it by clicking the "Open configuration" button.

9. To save your current Extract settings for future use, click the "Save" button and you will be prompted to select a location and a name for the file. It will be saved as a .ex file.

10. When you are finished using Extract, click the "Close" button. If this is the first time you have used Extract with the current settings or if you have modified a previously saved configuration file, you will be prompted to save your extract configuration for future use. If you would like to process this extraction in the future, click the "Yes" button, when prompted, to save your selections. Enter a name for the file and click "Ok". It will then be saved as a .ex file.

8.2   Aggregate

If you want to add together several projections to produce a total for a region, you can do that with the "Aggregate" function. This function will read the projections you specify and calculate them as though they are a single projection.

All indicators referring to numbers of people will be added across all projections. Rates, such as TFR and life expectancy, will be calculated as weighted averages. Weighting will be done by an appropriate population. For example, the TFR for the aggregate population will be calculated as the weighted average of the TFRs for each of the input projections, weighted with the number of women of reproductive age (15-49).

To use this feature, follow these steps:

After entering OneHealth, go to "Tools" and click on "Aggregate" icon. (Note: this command is not available if you have any projections open. If the command is not available, first click the round application button in the upper left corner of the screen and select "Close projection". If more than one projection is open the "Select projection" window will open. To close all projections select "All projections".) The Aggregate window will appear as follows:
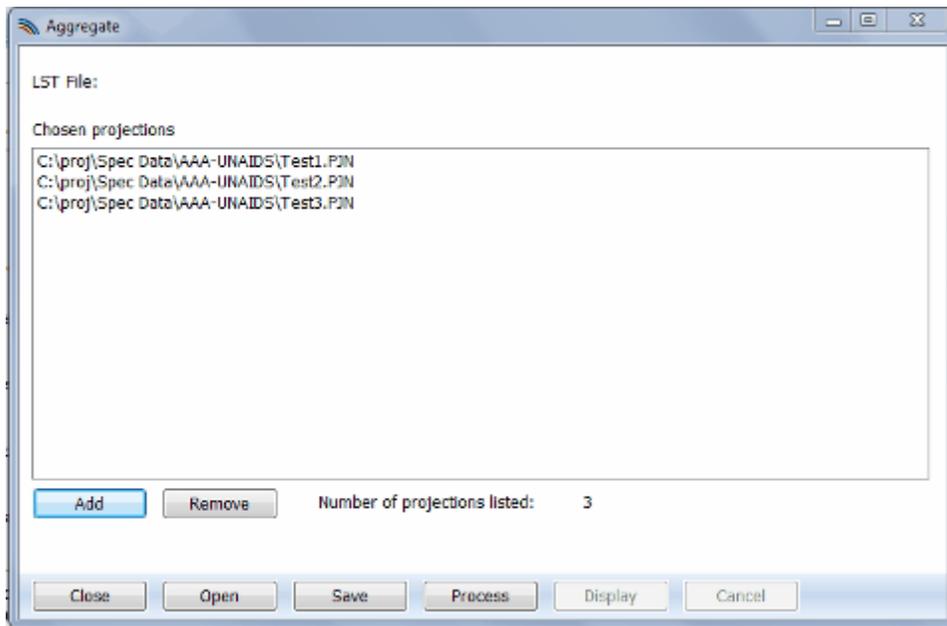
Click "Add" to browse previously saved projections. Click on the file name to highlight it, and then click "Open". You can select as many files as you want. To remove a selected projection from the "Chosen Projections", click on it to highlight it, and then click "Remove" to remove it.

If you would like to process this aggregation in the future, click the "Save" button to save your selections. Enter a name for the file and click "Ok". It will then be saved as an .LST file.

To process the aggregation, click the "Process" button. Once the files have been aggregated, "Processing complete" will appear in the lower right corner of the window and the "Display" button will be enabled as shown below:
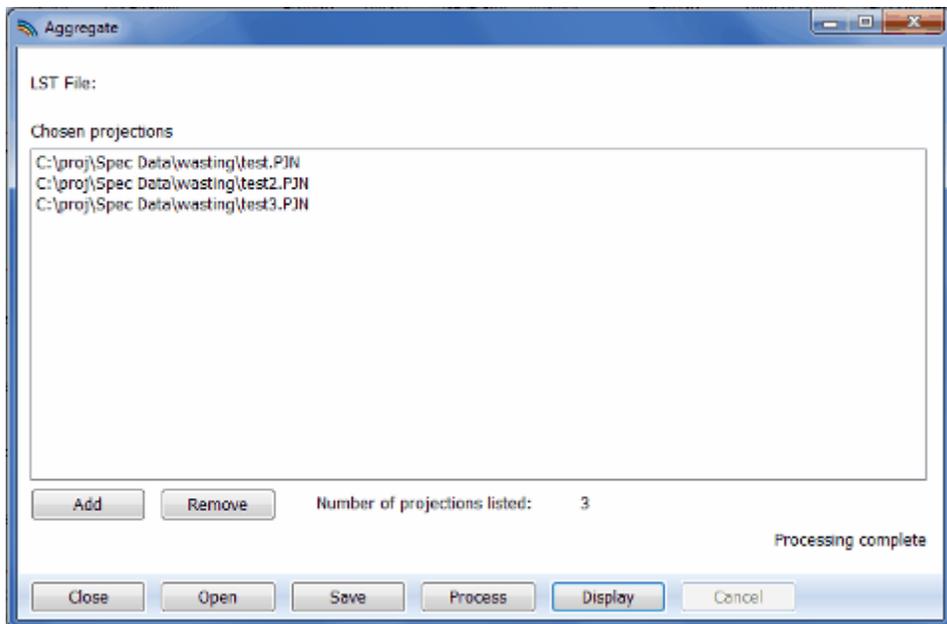
Click on the "Display" button to select and display the aggregated results for one of the summary tables listed in the drop down menu as shown below:
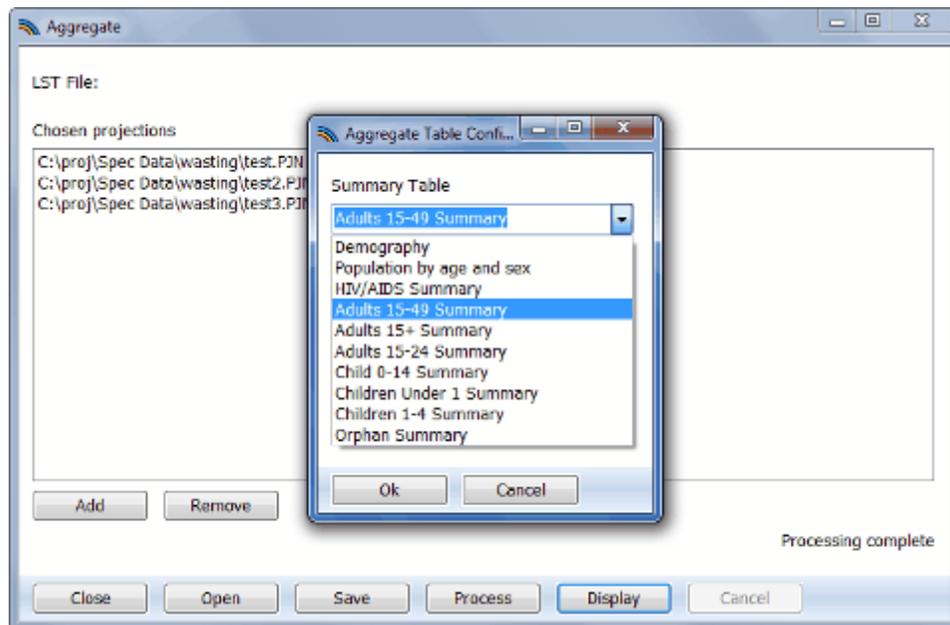
8.3 Scenario generator for AIM

The **Scenario Generator** tool enables you to vary the targets for PMTCT, Infant Feeding, Adult ART, and Child Treatment in order to project the course of the epidemic following and increase or decrease in the above targets (and thereby effort to achieve them).

After entering OneHealth, go to 'Tools' and click on 'Scenario Generator' from the drop-down menu. A 'Scenario Generator' window will open, in which the white 'choice' boxes will be empty. Below is an example of what the 'Scenario Generator' window looks like once filled in, followed by instructions on how to do so:
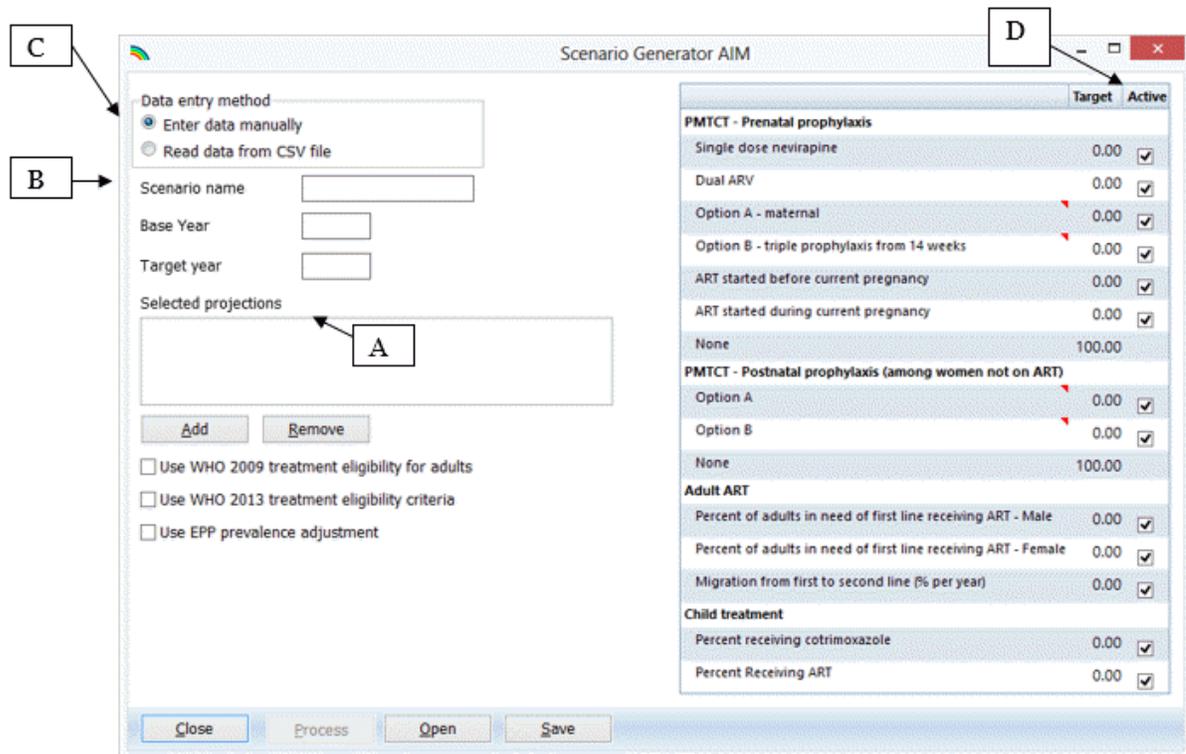
A. For the 'Selected Projections' box, click 'add' to browse and add a previously saved projection. Highlight a projection from the 'Chosen Projections' box and click 'remove' to remove it.

B. Choose a 'Scenario Name'. Then choose the 'Base Year' and 'Target Year' for which you wish to generate a scenario. Often, the base year is the current year.

C. The target data may then be entered manually, or it can be pulled from a CSV file by clicking on 'read from CSV File'. Highlight the CSV file you wish to choose in the 'Open' window, and click 'open'. CSV files are usually used rather than manual entry of the targets if a series of targets (matching the categories shown in the 'Scenario Generator' editor) were previously prepared in CSV files to speed the process of running a series of scenarios for comparison purposes. However, if a CSV file or files are used, Spectrum cannot interpolate between the base Year and Target Year. Therefore, the interpolation for each year must be done in the CSV file before importing into the Scenario Generator for application to the Chosen Projections.

D. Check the box in the 'Active' column if you want the Scenario Generator to use the target that is listed in the 'Target' column (either the default zero, or the target that you enter). If the 'active' box is left unchecked, a target will not be used for that variable and the scenario will be generated based on any prevention and/or treatment data that was entered to make the projection(s) for which you are generating the scenario.

To process the scenario generation, click the 'Process' button. Enter the file name you wish to save the scenario generation as, and click 'Ok.' It will then be saved as a Scenario Generator file (.SG file).

If you do not wish to process the scenario generation immediately, but would like to save the 'Scenario Generation' window in which you have pulled out the projections that you would like to generate scenarios for in the future, click the 'Save' button. Enter the file name you wish to save the 'Scenario Generator' window as, and click 'Ok.' It will then be saved as an .ex file.

8.4 Uncertainty analysis for AIM

The **Uncertainty analysis** tool will enable you to estimate the uncertainty associated with each variable. This analysis estimates the plausible range of values associated with each OneHealth variable.

Unlike other tools, you must have a single projection already open in OneHealth for the 'Uncertainty analysis' choice to appear.

Go to 'Tools' and click on 'Uncertainty Analysis' from the drop-down menu. An 'Uncertainty Analysis' window will open, in which the white 'choice' boxes will be empty. Below is an example of what the 'Uncertainty Analysis' window looks like once filled in, followed by instructions on how to do so:

Uncertainty Analysis	Mean	s.d.
Adults		
Ratio of fertility of HIV+ to HIV- women		0.10
Ratio of female to male incidence		0.05
Average number of years in CD4 count category		0.05
HIV mortality without ART		0.05
HIV mortality with ART		0.05
Children		
MTCT rates		0.05
Reduction in child mortality due to cotrimoxazole	0.33	0.10
Survival on ART		
Children Under 1 year old	0.80	0.08
Children Age 1 and older First Year	0.90	0.04
Children Age 1 and older Subsequent years	0.95	0.04

☐ Generate AIDS deaths CSV file

☐ Generate HIV+ CSV file

Number of iterations: 1000   1000

Process time: 23 min 20 sec   Process date: 2013-Jun-5

[Ok] [Cancel] [Process] [Display] [Export]

In Uncertainty dialogue box, set the number of iterations to be performed. Generally this number should be 1000. Once this is set, click the 'Process uncertainty analysis' button. Spectrum will do the requested number of iterations using the different prevalence curves read from EPP. Each projection will use different input values selected from ranges indicated in the bottom half of the dialogue box.

Once the analysis is complete you can view the results as graphs or tables by clicking 'Display.'

Once you are done examining the results, click the 'Ok' button. Spectrum will save the results to a file before quitting the procedure. If you press 'Cancel' instead of 'OK' the results will not be saved.

8.5   Aggregate uncertainty

The Aggregate tool allows you to aggregate various sub-national files to the national level. The Aggregate Uncertainty tool does the same thing but will also display the uncertainty bounds for the national results. Note that this tool only works if you have already run the uncertainty analysis for each sub-national file.

8.6   GAM

If you are producing an official estimates file for your country you may be asked to upload the results to the UNAIDS Global AIDS Monitoring system (GAM). This tool will read your Spectrum files, extract the data needed for GAM and write the data to a CSV file that can be imported into GAM on-line. To use the tool you first select the Spectrum file(s) using the 'Add' button. This could be a single national file or multiple sub-national files. Then specify the file name for the output by clicking the 'Set GAM result file name' button. Finally, click 'Process' to produce the file.

8.7   District estimates

Most countries apply the Spectrum model at the national level, but many also apply it at the province or state level. Detailed planning of interventions and resource allocation often happens at the next lowest level (districts). While Spectrum can be applied at the district level there are a number of challenges to doing do: demographic projections are more difficult because of the increased importance of migration, surveys may not be powered to provide reliable estimates at district level, and the number of individual Spectrum files required would be large and difficult to manage. Several approaches have been developed to estimate HIV prevalence at district level, including those that apply geospatial techniques to survey data and those that use small area estimation (SAE) techniques. These approaches estimate HIV prevalence at district level but not other indicators of interest, such as AIDS deaths and new infections by age and sex.

There are two tools in Spectrum to support district level planning: the District Estimates Tool and the Naomi District Estimates Tool. The District Estimates Tool, described here, uses prevalence among pregnant women at antenatal clinics to distribute key indicators by district. The Naomi District Estimates Tool, described in the next section, uses survey and program data to provide a more accurate picture of district HIV burden. The tool provides district estimates for people living with HIV, new infections, AIDS deaths, number on ART, ART coverage and PMTCT coverage. The tool works by disaggregating the national or provincial estimates from the Spectrum files to the districts within the nation or province such that the sum of the districts always matches the Spectrum totals. The disaggregation by district of people living with HIV (PLHIV), new infections and AIDS deaths is done on the basis of the distribution of PLHIV between the ages of 15-49. The number on ART is disaggregated on the basis of the number of adults (15+) or children receiving ART. To produce these estimates the tool requires inputs on the population 15-49, HIV prevalence among 15-49, numbers of adults on ART, numbers of children on ART and number of women receiving PMTCT services by district. The tool first calculates the proportion of people living with HIV (or adult ART or child ART) aged 15-49 at the provincial or national level that are in each district. These proportion are then used to disaggregate any of the Spectrum indicators. The same distributions are applied to any age and sex group.

This tool provides detailed district level estimates of key HIV indicators for HIV planning. It is designed to be useful for PEPFAR planning by providing key inputs into the develop of country operational plans. The main advantages of the tool are that it uses the official Spectrum estimates, ensures that all district estimate add up to the official provincial and national estimates, and provides a range of key indicators

and sex/age groups. The main limitation is that it applies the same proportion distribution by district to each indicator. The distribution probably is different by indicator, but little information is available on which to base estimates.

Using the tool requires the following steps:

1. Select the single national Spectrum file or the multiple sub-national Spectrum files that will be used to create the district estimates. You can save your configuration by clicking the menu icon next to the '?' icon and choosing 'Save. configuration'. If you have previously saved a configuration, you can open it by choosing 'Open configuration'. Then click the 'Next' button.

2. Enter the name of the districts in each province. Click the 'Add' button to add a line for a new district. For some countries you can read the district names from a master database by clicking the button 'Read districts from database'. The click the 'Next' button.

3. Enter the necessary information for each district. This is the population 15-49, the HIV prevalence among antenatal clinic attendees, the number of adults on ART, the number of children on ART and the number of pregnant women receiving treatment. These data should be for the most recent year available. When you finish, click the 'Next' button.

4. Set the display year using the drop down list at the bottom of screen.

5. Select the information you want to display. First select the indicator from the drop down menu, then select the age group, then select the sex, and, finally, click the 'Add result' button to add the result to the list. You can add as many indicators as you want. Then click the 'Next' button to see the results. Alternatively, you can click the button 'Load standard table' to get a detailed table with information on all indicators, both sexes and age groups 0-14, 15-49 and 50+.

6. Examine the results. You can right click inside the table and select 'Copy All' from menu to copy the results to the Windows clipboard. You can then paste them into Excel, Word or some other program.

7. If you want to transfer these results to a CSV file that can be read by the PEPFAR datapack, click the 'Export to datapack' button. This will create a CSV file. To read this CSV file into Excel with the correct formatting use the following steps:

   - Open Excel and select Blank workbook
   - Select 'Data' from the horizontal menu, then select 'From Text/CSV' from the tool bar
   - Select the datapack CSV file you just saved and click the 'Import' button
   - Then click the 'Load' button

8. Save your configuration and data by clicking the 'Save' button.

8.8   Naomi district estimates

Most countries apply the Spectrum model at the national level, but many also apply it at the province or state level. Detailed planning of interventions and resource allocation often happens at the next lowest level (districts). While Spectrum can be applied at the district level there are a number of challenges to doing do: demographic projections are more difficult because of the increased importance of migration, surveys may not be powered to provide reliable estimates at district level, and the number of individual Spectrum files required would be large and difficult to manage. Several approaches have been developed to estimate HIV prevalence at district level, including those that apply geospatial techniques to survey data and those that use small area estimation (SAE) techniques. These approaches estimate HIV prevalence at district level but not other indicators of interest, such as AIDS deaths and new infections by age and sex.

There are two tools in Spectrum to support district level planning: the District Estimates Tool and the Naomi District Estimates Tool. The District Estimates Tool, described in the previous section, uses prevalence among pregnant women at antenatal clinics to distribute key indicators by district. The Naomi District Estimates Tool, described here, uses survey and program data to provide a more accurate picture of district HIV burden. The tool provides district estimates for a number of indicators (population, HIV prevalence, people living with HIV (PLHIV), ART coverage, the number of people on ART, HIV incidence and new infections) by sex, age time period and district. The tool uses information from national household surveys and program information on ART patients to estimate distict level indicators.

This tool provides detailed district level estimates of key HIV indicators for HIV planning. It is designed to be useful for PEPFAR planning by providing key inputs into the develop of country operational plans. The main advantages of the tool are that it uses the most recent survey and program data, uses the official Spectrum estimates, ensures that all district estimate add up to the official provincial and national estimates, provides a range of key indicators and sex/age groups.

Using the tool requires the following steps:

1. Under the Tools menu, select the Naomi District Estimates Tool.

2. Click the button 'Generate district results'. This will take you to the Naomi website app where you can upload your data, run the analysis and view the results.

3. Once you have finished with the Naomi website and returned to Spectrum, load the Naomi results by clicking the button 'Read results' and selecting the Naomi output file, which will have a '.zip' extension.

4. Once you have read the Naomi results you can display the results by selecting an indicator, an age group and a time period from the drop down lists. Use the radio button to display the results as a table or a map.

5. Examine the results. You can right click inside the table and select 'Copy All' from menu to copy the results to the Windows clipboard. You can then paste them into Excel, Word or some other program.

6. If you want to transfer these results to a CSV file that can be read by the PEPFAR datapack, click the 'Export to datapack' button. This will create a CSV file. To read this CSV file into Excel with the correct formatting use the following steps:

   - Open Excel and select Blank workbook
   - Select 'Data' from the horizontal menu, then select 'From Text/CSV' from the tool bar
   - Select the datapack CSV file you just saved and click the 'Import' button

- Then click the 'Load' button

8.9   Scenario Generator for LiST

Scenario Generator allows users to create scale-up functions for multiple projections at a single time. The result of a Scenario Generator run will be new projections with new names (each with a prefix added onto the original file name) in a designated location. Each projection will have interventions scaled up in accordance with the options selected in the Scenario Generator menu.

1. After entering OneHealth, go to "Tools" and click on "LiST," then select "Scenario Generator." Note that this can only be selected if there are no projections currently open.

2. Select the "Enter data manually" toggle button in the top left of the page.

    NOTE: There is also an advanced feature that allows users to automatically upload an Excel file with pre-loaded scale-ups. There are no checks in this method and the developers are not responsible for the results.

3. Choose the "Intervention Year" and "Target Year." The "Intervention Year" should be the year from which you intend the scale-up to begin. No changes will occur in the "Intervention Year"; they will begin in the following year. The "Target Year" is the year in which the full scale-up target will be achieved. A linear scale-up will occur between these years.

4. Choose a "Scenario Name." This is the prefix will be added to the front of the projection name for all projections selected.

5. Under the "Selected Projections" box, click "Add" to browse and add previously saved projection(s). If necessary, you may highlight a projection in the "Selected Projections" box and click "Remove" to remove it.

6. Select where to save the new projection(s) by clicking on the file folder icon beneath "Save projections in the following location" and choosing from the drop-down list.

7. Check the boxes in the "On/off" column next to the indicators you wish to modify in your scale-up scenario.

8. In the Target year column, click on the box in the row for each intervention you want to include and enter in a target coverage. If the "scale to target percentage" option is selected above, then each projection in the scenario will have the intervention scaled up to that target coverage level. (For example, if "Folic acid supplementation/fortification" is checked and a target coverage of 80% is selected, each projection will be scaled up from its current level in the intervention year to reach 80% in the target year.) If the "scale by percentage points" option is selected above, then each projection in the scenario will have the intervention scaled up by the target number of percentage points over the course of the coverage period. (For example, if "Folic acid supplementation/fortification" is checked and a target coverage of 20% is selected, and the period from "Intervention year" to "Target year" is 10 years, each projection will be scaled up from its current level in the intervention year by 2% per year, for a total increase of 20 percentage points over the 10-year scale-up period.)

9. To launch the scenario generation, click the "Process" button.

There are several additional features that can be selected prior to selecting the "Process" button. They are all optional.

- By default, within Scenario Generator, LiST does not allow coverage to drop below the current level in the intervention year. It will maintain current coverage values, rather than scaling coverage down if the target coverage is below current coverage. If you do not want this feature, check the box next to "Allow coverage to decline from the impact year to the target year."

- Check the "Flatline unchecked interventions" box if you would like the program to keep coverage constant from the intervention year to the target year for all interventions that are unchecked in the "On/off" column. Often, this will be the preferred choice, as it allows you to project the impact of only the intervention(s) that you select in the "On/off" column and set a target coverage for (holding all other interventions constant). However, in some cases users may have previously prepared projection files that have target coverage already entered for a specified set of indicators, and they may wish to keep those coverage settings with the exception of one (or more) indicators for which a new target coverage will be applied through Scenario Generator. In that case, the "Flatline unchecked interventions" box should remain unchecked.

- In the standard Scenario Generator window, the delivery interventions are packaged and modeled together. If you would like to scale up individual interventions that occur during delivery, check the box "Use detailed childbirth coverage." Note that after using this, there may be complications with modifying coverage. These are intentional. The user is responsible for all post-hoc modifications. You can choose to scale up location/level of delivery or interventions specifically. If you would like to scale up location, uncheck the box next to "Allow LiST to calculate place and level of delivery." If you want to scale up interventions, uncheck the box "Allow LiST to calculate intervention coverages." Within this table, any unchecked boxes will be unaltered; only checked boxes will have their coverage values changed. Click OK to exit this screen. After exiting, if you do not want to include these assumptions, uncheck the box next to "Use detailed childbirth coverage."

- If you do not wish to process the scenario generation immediately, but would like to save the Scenario Generator parameters you have specified for future use, click the "Save" button. Enter the file name you wish to save the "Scenario Generator (LiST)" window as, and click "Save." It will then be saved as an .SGLiST file. If you have a previous set of parameters saved as an .SGLiST file, you may open it by clicking the "Open" button.

8.10   Equity Tool for LiST

The Equity Tool is a visualization tool that explores the effect of individually scaling up interventions from the current national average to the coverage level of the top wealth quintile (richest 20% of the country's population), to see which intervention scale-up would allow for the greatest number of lives saved. This allows users to explore the impact of within-country inequality in intervention coverage on maternal and child mortality.

The methodology and functionality of this tool are similar to Missed Opportunities, except that rather than scaling each intervention up to a target of 90% (as in MO), the scale-up target is the coverage of that intervention for the top wealth quintile in that country.

Note: The Equity Tool is only available for countries that have at least one household survey that is disaggregated by wealth quintile.

For more information on the methodology of the Equity Tool, please see Clermont A. The impact of eliminating within-country inequality in health coverage on maternal and child mortality: a Lives Saved Tool analysis. *BMC Public Health* 2017; 17(Suppl 4): 734. https://doi.org/10.1186/s12889-017-4737-2.
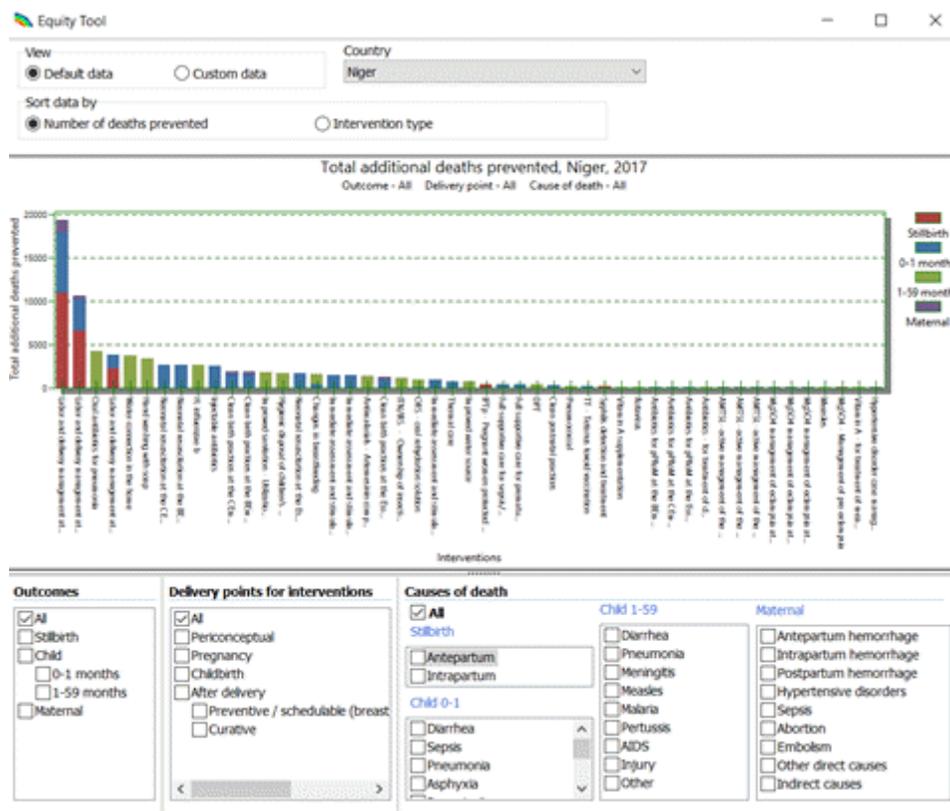
8.11   Missed Opportunities for LiST

Missed Opportunities (MO) is a visualization tool for quickly comparing the relative impact of different interventions reaching universal coverage on saving children's and women's lives. The MO tool draws on data from LiST to enable program managers and country health planners to explore intervention effectiveness in a rapid and comparative manner. As its name implies, if these proven interventions do not reach every child and woman in need, the potential deaths averted will become "missed opportunities."

The tool explores the effect of individually scaling up interventions from the current coverage level to 90%, to see which intervention scale-up would allow for the greatest number of lives saved.

Note: Missed Opportunities is only available for countries that have an under-five mortality rate of greater than 20 per 1,000 live births and that have at least some household survey data. If you would like to apply MO to another country, you may use the custom data option described below.

Note: Contraceptive prevalence is not displayed in the MO results by default, but can be shown by clicking on "Contraceptive prevalence" and checking the box underneath. This shows the impact of *reducing unmet need* for contraception by 90%.

For more information on the methodology of Missed Opportunities, please see Tam Y, Pearson L. Using the missed opportunity tool as an application of the Lives Saved Tool (LiST) for intervention prioritization. *BMC Public Health* 2017; 17(Suppl 4): 735. https://doi.org/10.1186/s12889-017-4736-3.
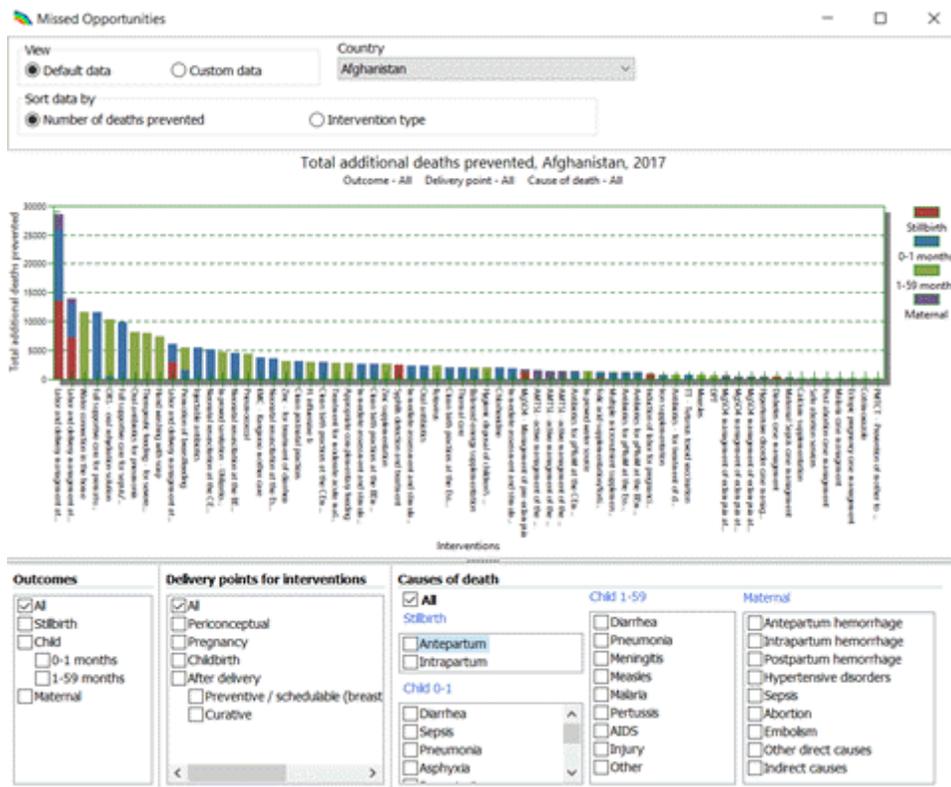
To run Missed Opportunities:

1. From the start screen, click the "Missed Opportunities" button. Alternatively, once in Spectrum, go to "Tools" and click on "LiST," then select "Missed Opportunities." Note that this can only be selected if there are no projections currently open.

2. You may use default data, based on the data that is available in the LiST database. This is updated regularly to ensure coverage is up-to-date. Alternatively, you may load custom data by creating a Missed Opportunities file. To do this, click the "Create Missed Opportunities file" button, then click the "Add" button in the pop-up menu window to select the projections you would like to use for custom data. Then click "Process," and a .MO file will be saved in the same folder as your projection. You can then click the "Load Missed Opportunities data" button on the main MO screen to use it.

3. Select the country of interest at the top of the screen. Note that limited intervention data may be available for some countries. You can click on any bar within the graph to see the current coverage level of that intervention (from which it is being scaled up to 90%). Any intervention that is not displayed has a current coverage level of above 90% and thus does not contribute any lives saved.

4. By default, the interventions are ordered in decreasing order of number of deaths prevented (when each intervention is scaled up to 90% coverage). You may choose to instead order them by intervention type (according to the categories as ordered in the "Coverage" tabs).

5. You may use the menus at the bottom of the screen to view results by outcome type (stillbirths, neonatal deaths, child deaths, maternal deaths), by delivery point for interventions, or by cause of death.

8.12 Subnational Wizard for LiST

The Subnational Wizard (SW) is an application linked to the Lives Saved Tool that be used to model outcomes for any subnational region or population group (by province, wealth quintile, geographic residence, etc.) Mortality rates and cause of death profiles are not typically available at the subnational level and this approach uses the differences in subnational intervention coverage, compared to national level coverage, to estimate baseline mortality and causes of death. Following the steps of the SW allows users to create a subnational baseline model using available data sources or relevant proxies that have been adjusted. The baseline model can then be edited to include intervention scale up for LiST analysis.

Additional information subnational modeling can be found here.

To use the Subnational Wizard:

1. After opening Spectrum, go to "Tools" and click on "Subnational Wizard." Note that this can only be selected if there are no projections currently open.

2. Users should gather estimates of the following to enter into the wizard.
    - Population
    - Total fertility rate
    - Contraceptive prevalence rate
    - HIV incidence

3. Coverage can be collected by the user or read-in automatically by the tool. To pick a region, select the country, subnational level of interest, and survey on the "Projection manager" page. Subnational data are drawn from DHS, MICS, and other nationally representative household surveys.
    Note: Data may be unavailable at the subnational level due to sample size, lack of collection, etc. In most cases where there are no data available, the SW automatically uses the national level data as a proxy. When stunting, wasting, and breastfeeding prevalence are not available at the subnational level, the national level data are adjusted by the ratios below.
    - Stunting: Subnational -2SD prevalence, 0-36 months/National -2SD prevalence, 0-36 months
    - Wasting: Subnational -2SD prevalence, 0-36 months/National -2SD prevalence, 0-36 months
    - Breastfeeding: Subnational exclusive breastfeeding prevalence, 0-5 months/National exclusive breastfeeding prevalence, 0-5 month

For more information about this tool, please contact info@livessavedtool.org

8.13   OHT scenario generator

8.13.1   Scale-up period

The OneHealth Scenario Generator will attempt to scale up intervention coverages to the specified target coverages within the selected scale-up period. However, if the first year of scale-up is less than the first year of a projection, OneHealth will start scale-up from the first year of the projection. If the final year of scale-up is greater than the final year of costing of a projection, OneHealth will end scale-up at the final year of costing of the projection.

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