SexWork

Impact Model
Version 3.0, December 1999

A tool to estimate the impact of
interventions working with sex workers
and their clients

December 1999

UNAIDS and the
Health Economics and Financing Programme
Health Policy Unit
London School of Hygiene & Tropical Medicine

HIVTools
A cost-effectiveness
toolkit for policy makers

SexWork

Sex Worker Intervention Impact Model
Version 3.0, December 1999

A tool to estimate the impact of HIV prevention activities focused on sex workers and their clients

Developed by:
Charlotte Watts
Peter Vickerman
Thierry Mertens
Stefano Bertozzi
Oussama Tawil

Contact address for further information:
Dr. C. Watts
Health Policy Unit
London School of Hygiene and Tropical Medicine
Keppel Street, London WC1E 7HT, UK
Tel: +44 171 927 2176
Fax: +44 171 637 5391
e-mail: C.Watts@lshtm.ac.uk

Acknowledgements

The model was field-tested in Cameroon, with the assistance of Alexis Boupda-Kuate and Jean-Claude Foumena of AIDSCAP Cameroon, and Claude Cheta and Zakariou Njoumemi of IRESCO

Funded by UNAIDS
Charlotte Watts and Peter Vickerman are members of the Health Economics and Financing Programme, which is funded by the Department for International Development of the UK.

1. Introduction to model and project

1.1 Background

A collaborative research project between the UNAIDS and the London School of Hygiene and Tropical Medicine, has been working since 1994 to develop methodologies to determine the costs and likely impact of five HIV prevention strategies - the strengthening of blood transfusion services, condom social marketing projects, school education, the strengthening of sexually transmitted disease (STD) treatment services, interventions working with sex workers and their clients, and interventions working with injecting drug users.

'*HIVTools*: a cost-effectiveness toolkit for HIV prevention' is currently being developed. *HIVTools* consists of 1) a set of simulation models that estimate the impact on HIV and STD transmission of different HIV prevention activities, and 2) guidelines for costing different HIV prevention activities. *HIVTools* aims to be a flexible and easy to use product, designed for policy makers, programme managers and AIDS Service Organisations working to address HIV and STD transmission. It can be used to estimate the impact, cost and cost-effectiveness of different HIV prevention strategies in different settings.

SexWork 3.0 is one of five simulation models within *HIVTools*. *SexWork 3.0* can be used, within a particular setting, to estimate the impact on HIV transmission of interventions focusing on sex workers and their clients. It can also be used to explore the likely impact of different policy options. The program simulates the transmission of HIV and STD infection between sex workers and their clients, both in the presence and absence of an intervention. The extent to which a sex worker intervention may avert HIV infection is modelled using context specific epidemiological and behavioural information, and estimating the coverage of the intervention among the overall sex worker population in any one location, how the intervention alters the distribution of condom use among sex workers recently reached by the intervention, and/or the extent to which sex workers receive intervention related STD treatment services.

The modelling approach adopted for *SexWork 3.0* differs from that taken by a number of other research groups, whose models focus on simulating the long term demographic impact of HIV infection, and are used to project long term trends in HIV prevalence and incidence. In contrast, from conception, the aim was that *SexWork 3.0* would be a simple tool that could be used to provide applied, intervention specific insights of use to Program Managers and policy makers at the national and local level. For this reason, the model's structure has intentionally been kept as simple as possible, and geared towards using the routine forms of monitoring and evaluation data currently being collected by interventions focusing on sex workers and their clients. The model has a selected range of inputs, linked to the main factors thought to influence the impact of an intervention. Certain possibilities, where there was little behavioural and evaluation data, were not included in the model. As more information becomes available, it may be necessary to modify the program's structure to

reflect changes in understanding. In some cases, it may also be important to stratify the sex worker population (such as by levels of sexual activity), and to apply the model separately to each strata.

It is hoped that *SexWork 3.0* can be used to improve understanding of the impact of interventions focused on sex workers and their clients, to identify some of the key features influencing their impact in different settings, and to inform policy.

1.2 Key features of *SexWork 3.0*

- A dynamic mathematical model of the transmission dynamics of HIV and STD infection between sex workers and their clients that can be used to obtain:
  - Short-term estimates of the number of HIV infections averted among sex workers and their clients
  - Trends in HIV and STD infection in the presence and absence of an intervention
  - Trends in HIV incidence in the presence and absence of an intervention
  - Trends in HIV infection among sex workers with different levels of consistency of condom use.

- *SexWork 3.0* aims to use the forms of behavioural, epidemiological and intervention process and outcome data that are commonly collected by interventions working with sex workers and their clients.

- *SexWork 3.0* incorporates a range of intervention specific inputs, which enable the user to explore the short term effects of different forms of intervention activity on the overall patterns of HIV and STD transmission among sex workers and their clients, and the numbers of HIV infections averted over a specified time.

- *SexWork 3.0* is a self-contained piece of computer software, that aims to be user friendly to a broad range of individuals concerned about HIV transmission between sex workers and their clients.

1.3 Development and distribution of *SexWork 3.0*

The initial structure of the model developed is the result of a series of consultations with staff at WHO and UNAIDS, and followed a review of the literature on HIV prevention activities working with sex workers and their clients. Simple flow charts were used to describe the model structure and underlying assumptions. These were used to enable a range of groups to guide the model's structure. The model and its underlying assumptions were field tested in Cameroon in 1996. Informal discussions with key informants, and the findings from several epidemiological, behavioural and evaluation studies were used to assess the relevance, applicability and ease of use of the model. Further field-testing will be required to assess the more general

applicability of the model, and to refine its format to the needs of specific users.

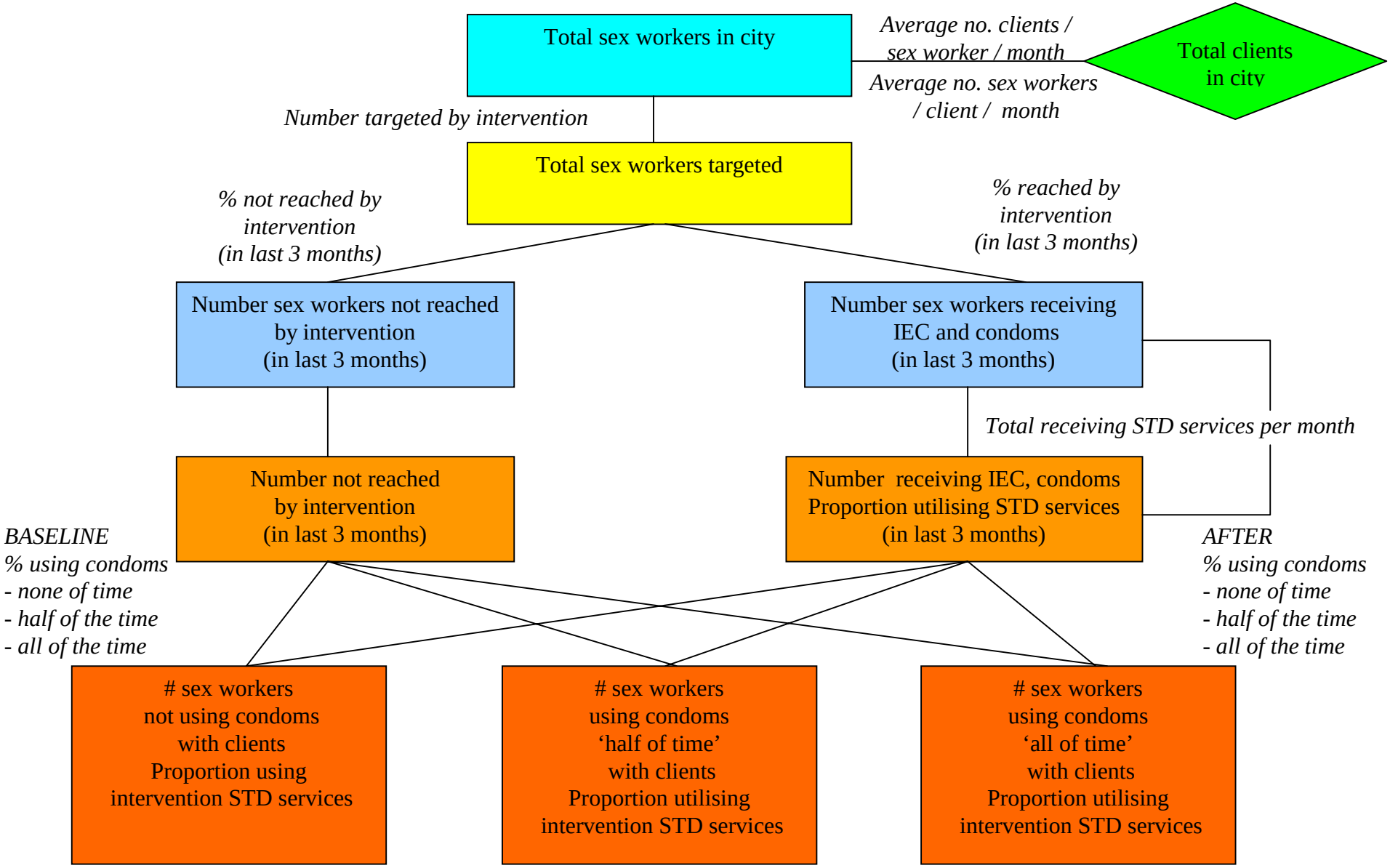
Version 3.0 was finalised in December 1998, and can be obtained free of charge from UNAIDS. It is likely that further revisions to the model will be made once feedback on its use has been obtained. Anyone who would like to receive up-dated copies of the model should write to London School of Hygiene and Tropical Medicine giving their contact details, and describing how they plan to use the model. They will then be sent the latest version of the model and an accompanying manual. Copies of any reports or publications arising from use of the model should be sent to UNAIDS, and to Dr. C. Watts at the London School of Hygiene and Tropical Medicine. Feedback on the model would also be greatly appreciated, and will be used to guide the future development of the package.

1.4 Model Outline

The program simulates the transmission of HIV and a generic STD infection between sex workers and their clients, both in the presence and absence of an intervention. The impact of the intervention is determined using context specific epidemiological data, estimates of the coverage of the project among the overall sex worker population in any one location, and measures of the impact of the intervention on reported levels of condom use, and sex workers' access to intervention related STD treatment services.

Figures 1 and 2 outline the conceptual framework and the main inputs of the model (*Section 2.2*).

INTERVENTION COVERAGE AND IMPACT ON PATTERNS OF CONDOM USE & USE OF INTERVENTION STD SERVICES



HIV AND STD TRANSMISSION DYNAMICS MODELLED

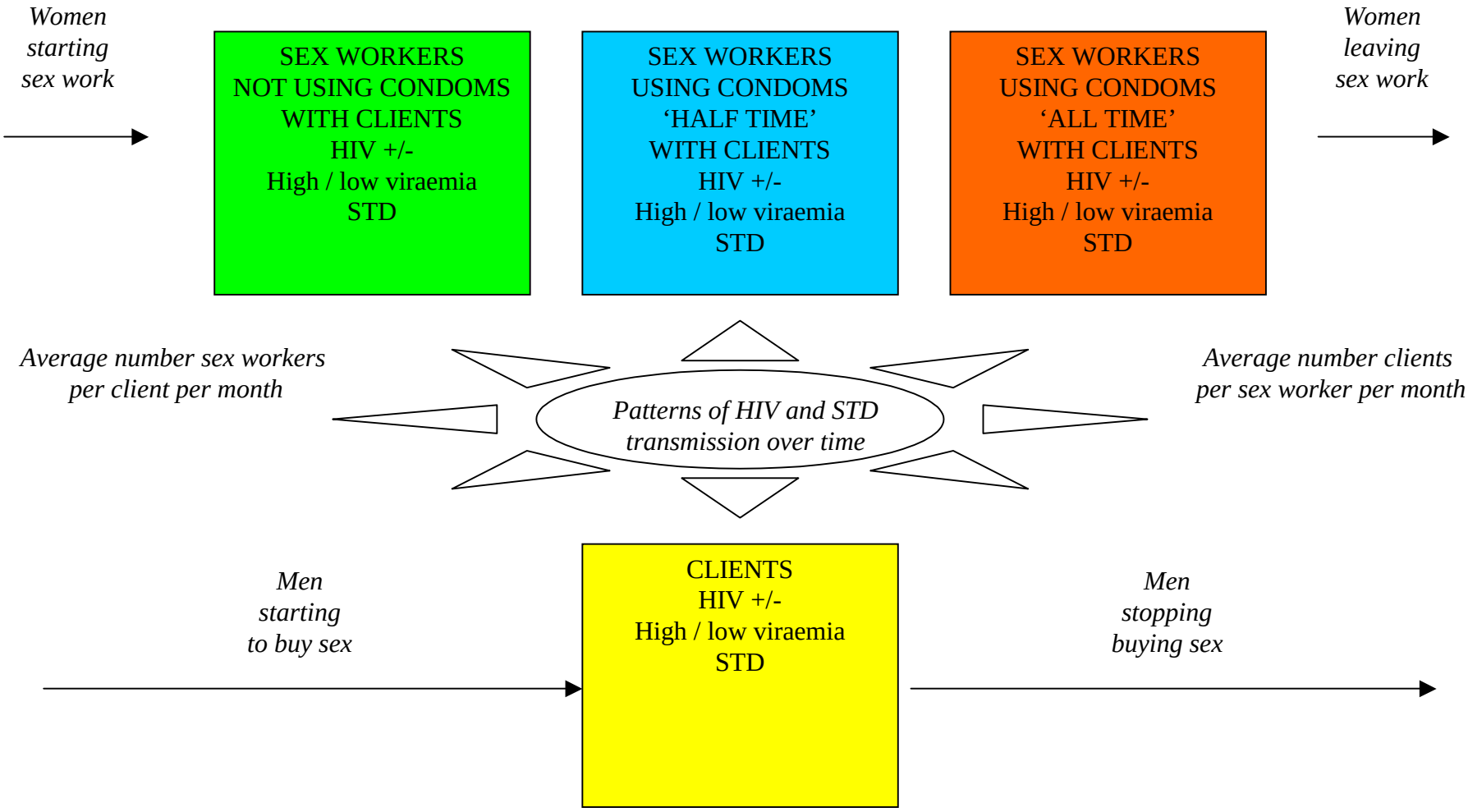


Figure 1 shows how demographic, behavioural and intervention processes and outcome evaluation data are used to estimate:

1) The total size of the sex worker and client populations in the city or location of interest
2) The numbers of sex workers recently reached by the intervention
3) The numbers of sex workers reached that have access to intervention related STD treatment services
4) The impact of the intervention on the overall distribution of condom use by sex workers.

In the figure, text written in italics represents inputs required by *SexWork 3.0*. Text that is not in italics represents information that is calculated from these inputs. Thus, for example, the overall distribution of condom use among the sex worker population in the presence of the intervention is calculated using inputs describing:

- the size of the overall sex worker population;
- the proportion of sex workers targeted by the intervention;
- the proportion of those targeted who have been recently reached by the intervention;
- information on the distribution of condom use among sex workers who have not been recently reached by the intervention;
- information on the distribution of condom use among sex workers who have been recently reached by the intervention.

Figure 2 outlines the structure of the HIV and STD transmission dynamics simulated by the model. The model simulates the patterns of HIV and STD transmission resulting from sexual contact between three groups of sex workers and a client population. Sex workers are divided into three categories: sex workers using condoms 'all of the time' with clients, sex workers using condoms 'half of the time' with clients, and sex workers who are 'not using' condoms. The distribution of condom use among sex workers is influenced by the baseline distribution of reported condom use, the extent to which the intervention reaches the overall population, and the degree to which contact with the intervention results in changes in reported condom use (as shown in *Figure 1*).

For simplicity, it is assumed that the sex worker population remains fixed in size over the timeframe considered. Sex workers may move out of commercial sex, either after a fixed duration of time or due to HIV-related morbidity, and are replaced by new, HIV susceptible, sex workers.

The client population is assumed to be homogeneous, and to randomly pick sex workers from each of the three condom use groups. Again, for simplicity, it is assumed that the client population remains fixed in size over the timeframe considered. Clients may stop buying sex, either after a fixed duration of time or due to

HIV-related morbidity, and are replaced by new, HIV susceptible, clients.

Because the transmission of HIV infection is facilitated by the presence of an STD, the model simulates how, over time, both a 'generic' STD and HIV infection may spread between sex workers and their clients both in the presence and absence of the intervention. As there is also an increased probability of HIV transmission during the initial high viraemia phase of HIV infection, at each point in time, HIV infected individuals are divided into those with early infections (in a high viraemia phase) and those with more long-term infections (in a low viraemia phase).

Section 3 describes in more detail the inputs required by the model. Details of the underlying mathematics are given in Watts, Vickerman and Vaughan (1999). A summary of the input values required and the default values used is given in Appendix 1.

2. Installing and running *SexWork 3.0*

2.1 Installing and opening *SexWork 3.0*

Version 3.0 of *SexWork* is a stand-alone program designed for use on an IBM-compatible computer. The program can be run in either a DOS (version 3.1 or higher) or a Windows environment. At present, the model is not in the public domain, and should not be distributed and copied. Once it has been further tested and finalised, it will become public domain software, which may be freely copied.

All of the files needed to run this program are on the floppy disk included with this manual. To install *SexWork 3.0*, you need to run the file SETUP.EXE, included on the floppy disk.

Installing and opening from Windows 95, 97 or 98*

Step 1. Close all running applications and insert the *SexWork 3.0* disk in your floppy disk drive

Step 2. In Windows Program Manager, choose Run from the [START] menu

Step 3. Type 'a:\setup', where a: is the letter of your disk drive, and press [Enter]. This will start the installation process.

Step 4. A dialog box [HIV Prevention Models Version 3.0 Setup] will appear on your screen. Use the mouse to select the [OK] button on the dialog box or press [Enter] to continue the installation process.

Step 5. Another dialog box [COLLECTING SETUP INFORMATION ....] will then appear on your screen. This gives details of the location and name of the directory in which the *SexWork 3.0* program files will be copied, the name of the program group in which the *SexWork 3.0* program icon will be placed, and the location of the installation files. By default, the installation process will create a directory on your C: drive called 'Models', to contain the program files; and will create a program group 'HIV Prevention Models', in which to place the *SexWork 3.0* program. The location and name of the directory, and/or the group name, and/or the location of the installation files can be changed by entering a different drive, directory name and/or group name

*. Windows 3.1, Windows 95, Windows 97 and Windows 98 are registered trademarks of Microsoft Corporation.

in the dialog box. Once you have made any desired changes, use the mouse to select the [NEXT>>] button on the dialog box or press [Enter] to continue.

Step 6. A warning dialog box will now be shown on the screen, warning that the installation process cannot be completed if other applications are running. If necessary, use the [Alt]-[Tab] keys to switch to any open applications, and then close them. Once all other applications are closed, select the [OK] button or press [Enter] to continue with the installation process.

Step 7. A dialog box will now be shown providing information on the progress made in installing *SexWork 3.0*. At any point, you can select the [ABORT SETUP] or press [Esc] to terminate the installation process. Once installation is complete, a dialogue box [CONGRATULATIONS!] will appear on the screen, to inform you that the model has been successfully installed. Select the [OK] button or press [Enter] to exit the installation program.

To run the program, click the *SexWork 3.0* model icon within the 'HIV Prevention Models' program group.

Installing and opening from Windows 3.1[1]

Step 1. Close all running applications and insert the *SexWork 3.0* disk in your floppy disk drive.

Step 2. In Windows Program Manager, choose Run from the [FILE] option.

Step 3. Type 'a:\setup', where a: is the letter of your disk drive, and press [Enter]. This will start the installation process.

Step 4. Step 4. A dialog box [HIV Prevention Models Version 3.0 Setup] will appear on your screen. Use the mouse to select the [OK] button on the dialog box or press [Enter] to continue the installation process.

Step 5. Another dialog box [COLLECTING SETUP INFORMATION ....] will then appear on your screen. This gives details of the location and name of the directory in which the *SexWork 3.0* program files will be copied, the name of the program group in which the *SexWork 3.0* program icon will be placed, and the location of the installation files. By default, the installation process will create a directory on your C: drive called 'Models', to contain the program files; and will create a program group 'HIV Prevention Models', in which to place the *SexWork 3.0* program.

The location and name of the directory, and/or the group name, and/or the location of the installation files can be changed by entering a different drive, directory name and/or group name in the dialog box. Once you have made any desired changes, use the mouse to select the [NEXT>>] button on the dialog box or press [Enter] to continue

Step 6. A warning dialog box will now be shown on the screen, warning that the installation process cannot be completed if other applications are running. If necessary, use the [Alt]-[Tab] keys to switch to any open applications, and then close them. Once all other applications are closed, select the [OK] button or press [Enter] to continue with the installation process.

Step 7. A dialog box will now be shown providing information on the progress made in installing *SexWork 3.0*. At any point, you can select the [ABORT SETUP] or press [Esc] to terminate the installation process. Once installation is complete, a dialogue box [CONGRATULATIONS!] will appear on the screen, to inform you that the model has been successfully installed. Select the [OK] button or press [Enter] to exit the installation program.

To run the program, click the *SexWork 3.0* model icon within the 'HIV Prevention Models' program group.

Installing and opening from DOS

Step 1. Close all running applications and insert the *SexWork 3.0* disk in your disk drive.

Step 2. Type 'a:' and press [Enter], where a: is the letter of your disk drive.

Step 3. Type 'a:\setup', where a: is the letter of your disk drive, and press [Enter]. This will start the installation process

Step 4. A dialog box [HIV Prevention Models Version 3.0 Setup] will appear on your screen. Press [Enter] to continue the installation process.

Step 5. Another dialog box [COLLECTING SETUP INFORMATION ....] will appear on your screen. This gives details of the location and name of the directory in which the *SexWork 3.0* program files will be copied, and the location of the installation files. By default, the installation process will create a directory on your C: drive called 'Models', to contain the program files. The location

and name of the directory, and/or the location of the installation files can be changed by entering a different drive, and/or group name in the dialog box. Once you have made any desired changes, press [Enter] to continue the installation process. Press [Esc] to terminate the installation.

Step 6. A warning dialog box will now be shown on the screen. This warns that the installation process cannot be completed if other applications are running. If necessary, use the [Alt]-[Tab] keys to switch to any open applications, and then close them. Once all other applications are closed, press [Enter] to continue with the installation process.

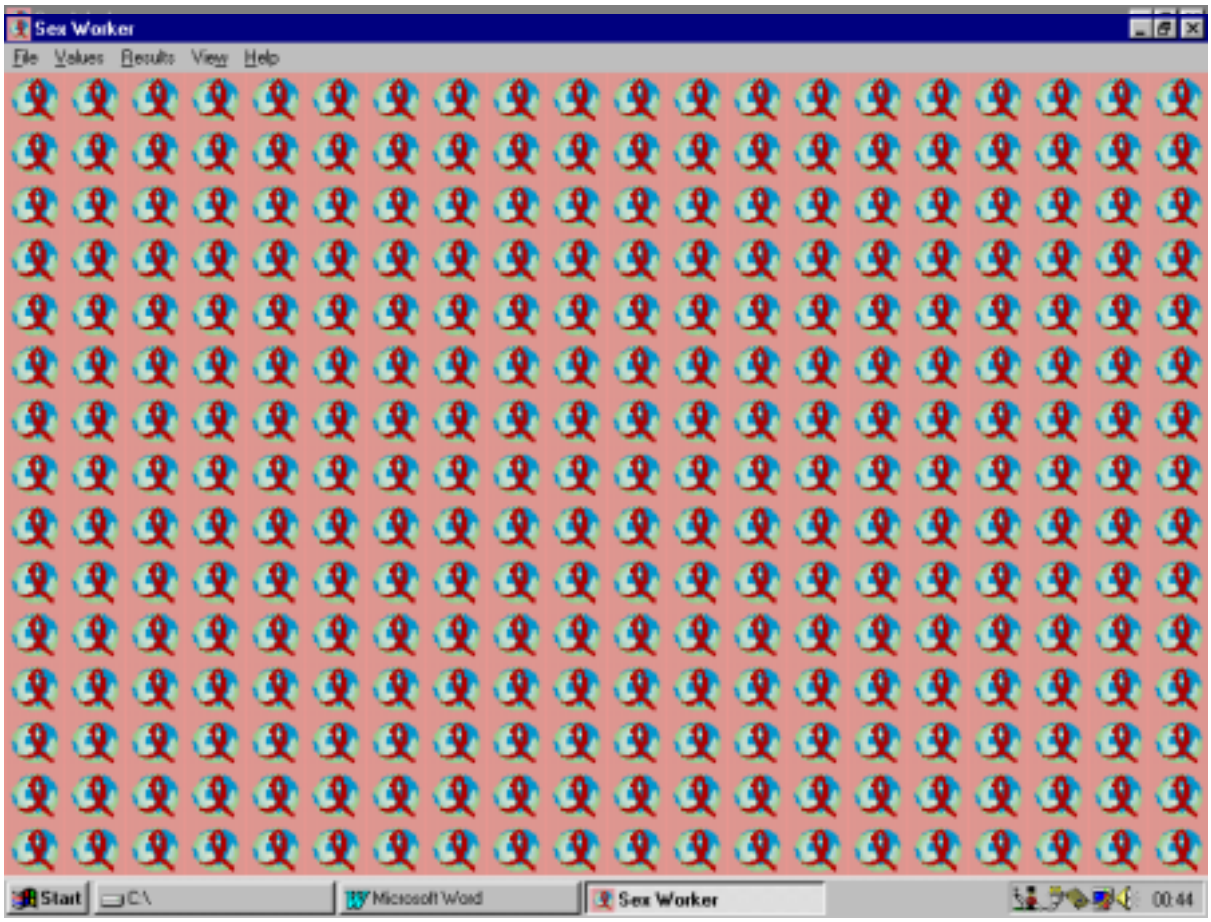
Step 7. A dialog box will now be shown providing information on the progress made in installing SexWorkAt any point, you can select the [ABORT SETUP] or press [Esc] to terminate the installation process. Once installation is complete, a dialogue box [CONGRATULATIONS!] will appear on the screen, to inform you that the model has been successfully installed. Press [Enter] to exit the installation program.

To run the program:

1. Type 'cd\models' and press [Enter] to change to the Model directory
2. Type 'swork' and press [Enter] to run *SexWork 3.0*.

2.2 Running *SexWork 3.0*

Once *SexWork 3.0* has been opened, a screen containing the Main Menu will appear:



Selecting menu headings and menu items

Within a windows environment, the mouse can be used to select menu headings and menu items, to enter data, and to select the format in which to view the results. In addition, or when running *SexWork 3.0* in a DOS environment, the following keys can be used:

Arrow keys The Up-Down and Left-Right arrow keys can be used to move up and down and between menu selections.

ENTER key The [Enter] key can be used to select menu options and to signal completed input of data into fields.

TAB key The [Tab] Key can be used to move in the forward direction between entry fields within any

of the menu selection screens. Using both the [Shift] and [Tab] keys together allows movement in the reverse direction between entry fields.

ESC key The [Esc] key can be used to return to a higher menu level.

ALT key The [Alt] key, in combination with one of the letters underlined in the list of menu options, can be used to view the menu options. The [Alt] key, in combination with one of the letters underlined in the list of menu selections, followed by the [Enter] key, can be used to select the option.

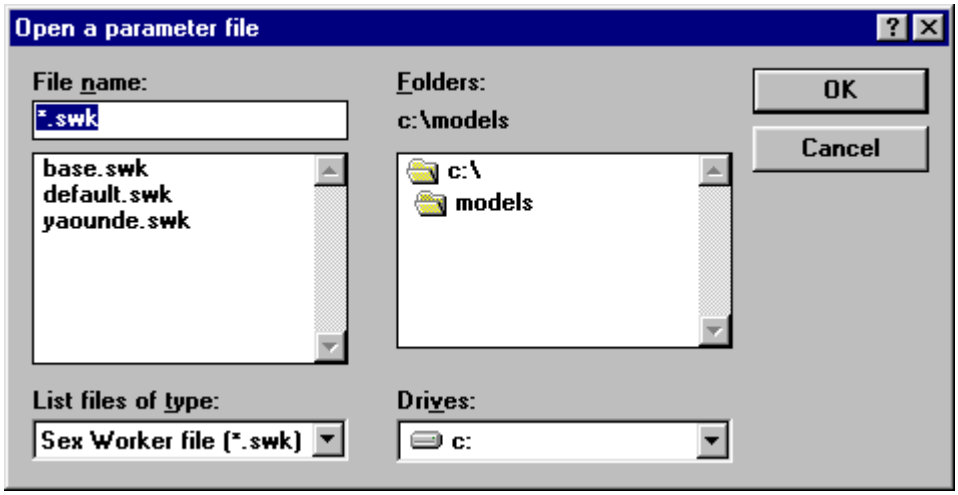
3. Menu headings

SexWork 3.0 has five primary menu headings: File, Values, Results, View and Help. These are described in turn below.

3.1 FILE

Within [FILE], it is possible to open new parameter files, edit existing files, access the default values, and exit the program. [FILE] can be selected using either the mouse, or by pressing the [Alt] and F keys together. Options within [FILE] can then be selected by using the mouse; using the down arrow key to move the highlighted bar down to the option required and pressing [Enter], or by pressing the [Alt] and the appropriately lettered key together.

File¦Open – can be used to locate and open saved files of input parameters. All input files for *SexWork 3.0* have the extension NAME.swk. When *SexWork 3.0* is opened, by default it will open the default parameter file. Existing files can be selected either by using the mouse, or by using the [Tab], arrow and [Enter] keys to move between folders and files.



File¦Save – can, in the same manner, be used to save the current input parameters in the open parameter file. It is not possible to alter the input values assigned to the default data input file.

File¦Save as ... – can be used to save the current input parameters in a new parameter file, with the extension NAME.swk. This can be used to develop, for example, files of input values from a sex worker

intervention being implemented in a particular setting.

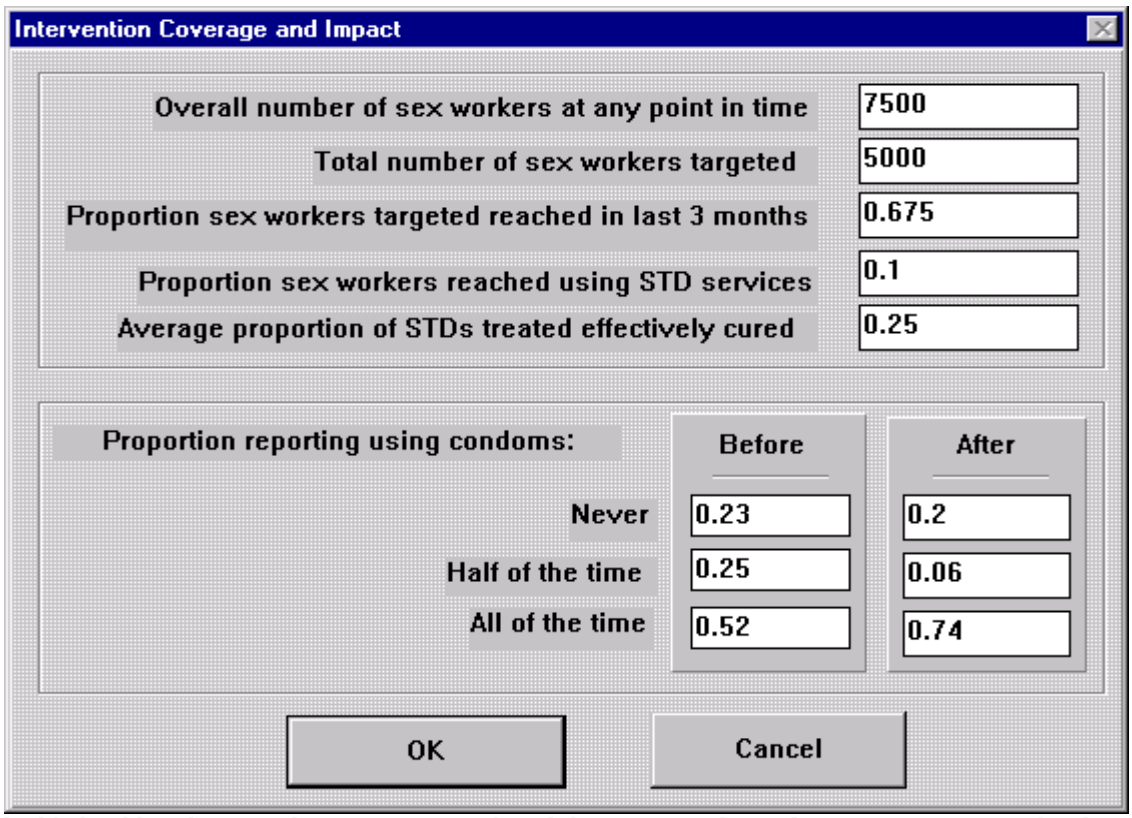
File¦Print - prints the current data output file.

File¦Exit - exits *SexWork 3.0.*

3.2 VALUES

The [VALUES] menu is used to change the input parameters used in the program simulations. Five sets of inputs are required: computational; epidemiological; behavioural; intervention coverage and impact; and transmission. Within [VALUES], it is possible to modify the inputs used to estimate the impact of a particular intervention. [VALUES] can be selected using either the mouse, or by pressing the [Alt] and V keys together. For illustration, the intervention coverage and impact input screen within [VALUES] is shown below.

Options within [VALUES] can be selected using the mouse; or by using the down arrow key to move the



highlighted bar down to the option required, and then pressing [Enter]. Once an option within [VALUES] has been selected, a list of inputs will be shown. The input values shown can be selected and altered either by using the mouse, or by using the [Tab] key or the [Tab] and [Shift] keys together to move between different entry fields. By clicking the OK button or pressing [Enter], the user can exit the option and return to the

[VALUES] menu. The input values shown at this point will be used in any subsequent calculations. More details about the [VALUES] menu are given in *Section 4*.

3.3 RESULTS

The [RESULTS] menu has only one option - [CALCULATE]. [RESULTS] can be selected using either the mouse, or by pressing the [Alt] and 'R' keys together. [CALCULATE] can be selected either by using the mouse, or by first using the down arrow key to move the shaded bar to [CALCULATE], and then using the [Enter] key to select this option. The model will then use the current input parameter set to iteratively simulate over time patterns of STD and HIV transmission between sex workers and clients, both in the presence and absence of the intervention.

3.4 VIEW

The outputs from a model simulation can be viewed in a number of ways. The projected trends in HIV and STD prevalence among different subgroups, with and without the intervention, can be viewed either in a data format or plotted on a graph. Estimates of the cumulative number of HIV infections averted by the intervention among sex workers and clients can also be viewed, in a data format and/or on a bar graph. The menu options within [VIEW] are listed below:

View¦Data outputs - shows the main data outputs for each month in a table.

View¦Graphs - the model output can be viewed in five different graphical forms, (see *Section 5.2*).

View¦Infections averted - shows a summary bar-chart of the estimated number of HIV infections averted each year among sex workers and their clients over the timeframe being considered.

View¦Summary sheet – gives a summary of the main inputs and model outputs.

View¦Flow charts –shows the flow charts outlining the conceptual framework and main inputs of the model.

3.5 HELP

The [ABOUT] option in the [HELP] menu gives a summary of the *SexWork 3.0*. A more detailed [HELP] function has not been developed.

4. Model inputs

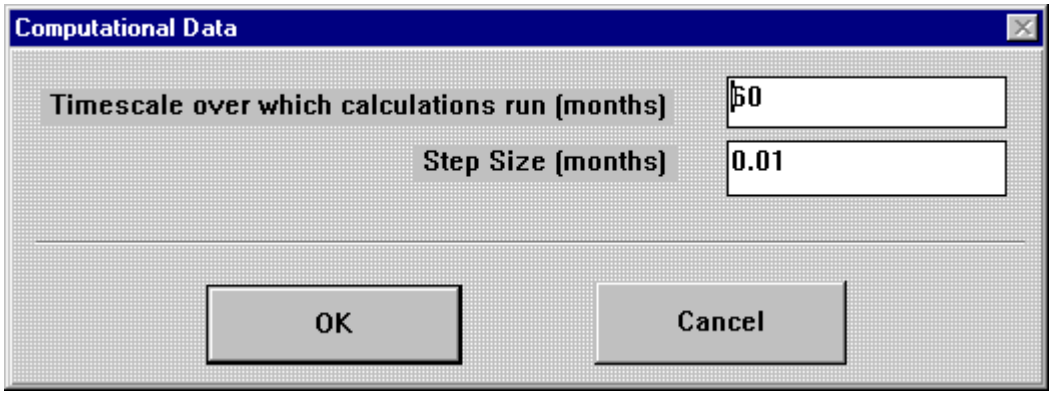
The model requires a range of input parameters, which are entered in the computational, epidemiological, behavioural, intervention coverage and impact, and transmission probability dialog boxes in the [VALUES] menu:

The [VALUE] menu can be used to change any of the input parameters used in the simulations. The mouse, arrow and return keys can be used to move between different input screens, and to change the model's inputs.

Where appropriate, limits on the possible range of different parameters have been specified in the model (such as proportions being greater than zero and less than one). Where a chosen number falls outside the permissible range, an error sign is displayed, and the user is given the option to input a different number. The model comes with a default set of pre-assigned behavioural, epidemiological and intervention specific inputs. Each time the program is opened, the set of input parameters revert to their default settings. Other sets of inputs can be saved in [FILE], under the header [SAVE].

Each of the dialog boxes are described below. The default values used are shown in the dialog boxes.

4.1 **Computational Data** - change computational inputs

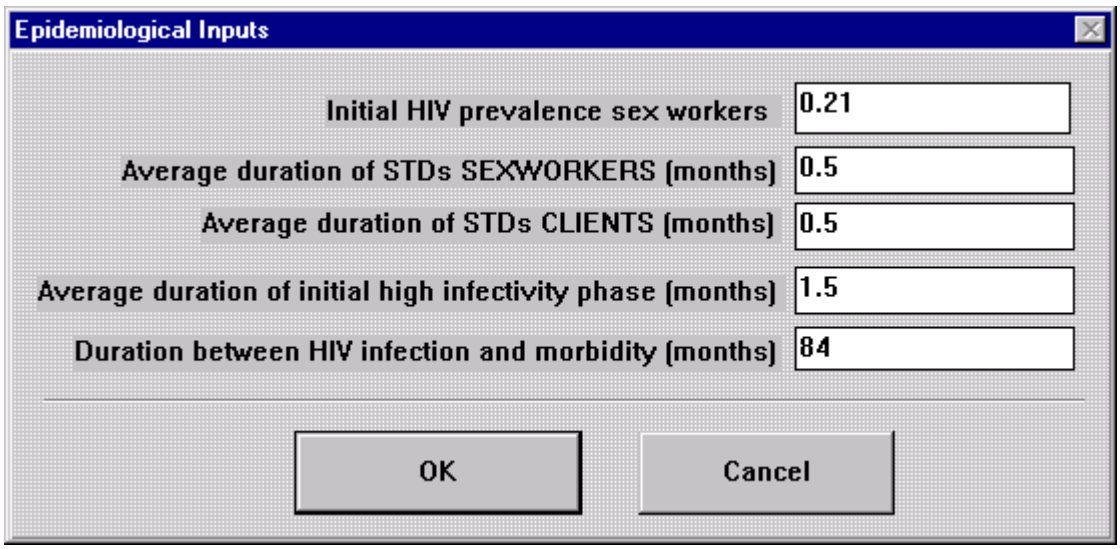


- Timescale over which calculations run (months) – this is used to define how long to run the calculations. We do not recommend using timescales greater than five years (60 months).

- Step size (months) – this is used to define the time period used for each iterative calculation of the distribution of HIV and STD infection (see appendix for further details). In general, the smaller the step

size used the better, and computational difficulties may arise if the step size used is too large. However, the use of too small a step size will result in the computations being slow. To identify an appropriate step size to use, run the model with the default step size. Halve the step size, and run the model again. If the results do not differ substantially, you may continue with the larger step size. If the results are different, you will need to again reduce the step size, and assess whether the results differ again. In this way, through trial and error, the most appropriate step size for any set of input parameters can be determined.

4.2 **Epidemiological Inputs** - change epidemiological inputs



- Initial HIV prevalence sex workers – Prevalence of HIV among sex workers at the start of the intervention.

- Average duration of STDs SEX WORKERS (months) - The average duration of STDs among sex workers, in the absence of STD treatment services provided by the intervention. The duration chosen should broadly reflect the accessibility and quality of STD treatment services available from sources other than the intervention.

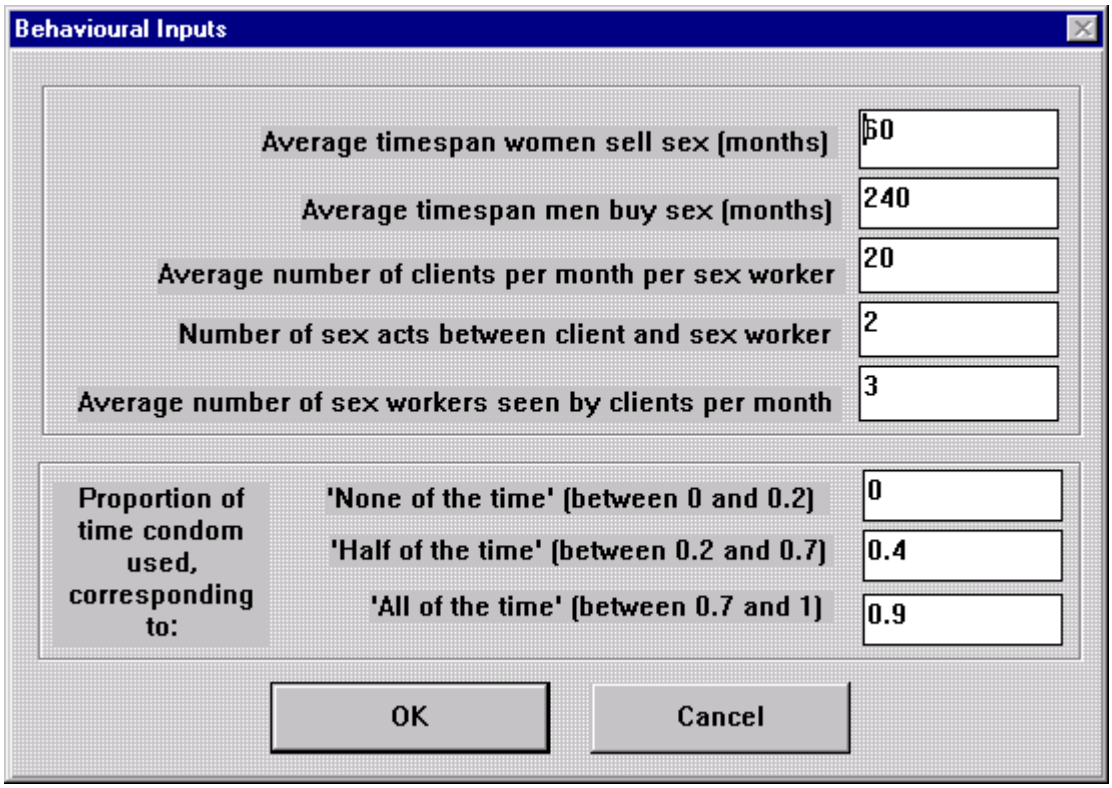
- Average duration of STDs CLIENTS (months) - The average duration of STDs among the clients of sex workers, in the absence of STD treatment services provided by the intervention. The duration chosen may reflect the accessibility and quality of STD treatment services available to clients.

- Average duration of initial high infectivity phase (months) - Average duration of the observed initial high viraemia phase of HIV infection. At present, it is not thought that this duration varies

substantially between settings.

- Duration between HIV infection and morbidity (months) – Average time between acquiring HIV infection and ceasing sexual activity due to HIV related morbidity. This may vary between settings.

4.3 **Behavioural Inputs** - changes behavioural inputs



- Average timespan women sell sex (months) - Average duration that a woman sells sex. This is likely to vary substantially both between locations, and possibly between different socio-economic groups.

- Average timespan men buy sex (months) - Average duration men continue to buy sex from sex workers. This is likely to vary substantially between locations. For example, in some settings it may be that many men commonly buy sex for a period of time before marriage, and cease this after marriage. In other settings, it may be that men continue to buy sex after marriage.

- Average number of clients per month per sex worker – Average number of different clients that a sex worker has sex with each month. This is likely to vary substantially both between settings, and between different socio-economic groups of sex workers. Where there is a wide range of variation in the

average number of clients per month per sex worker, it may be most appropriate to stratify the sex worker population into broad classes with different levels of sexual activity, and then to run the model separately for each strata.

- Number of sex acts between client and sex worker - average number of sex acts between a sex worker and a client.

- Average number of sex workers seen by clients per month – average number of different sex workers that a client has sex with each month. This is likely to vary both between settings and between different socio-economic groups of men.

- Proportion of time condom used, corresponding to:

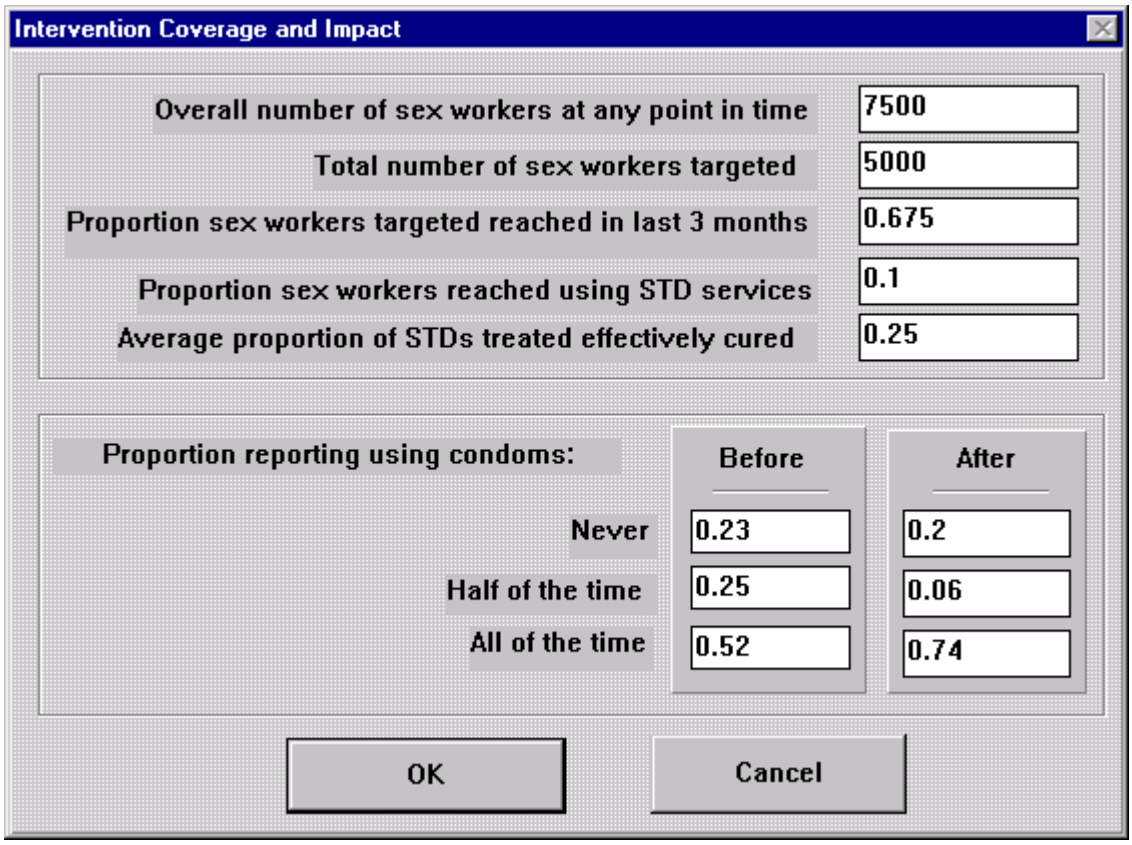
  a) 'None of the time' (between 0 and 0.2) - fraction of sex acts in which a condom is used that corresponds to when a sex worker reports that a condom has been used 'none of the time' with clients.

  b) 'Half of the time' (between 0.2 and 0.6) - fraction of sex acts in which a condom is used that corresponds to when a sex worker reports that a condom has been used 'half of the time' with clients.

  c) 'All of the time' (between 0.6 and 1) - fraction of sex acts in which a condom is used that corresponds to when a sex worker reports that a condom has been used 'all of the time' with clients.

These inputs can be changed to reflect the quality of the behavioural data being used in the simulations. For example, it may be that the reported use of condoms 'all of the time' is interpreted as 60% of the time, or 90% of the time. Sensitivity analysis can be used to assess the robustness of the model's projections to changes in these assumptions.

4.4 Intervention Coverage and Impact - change the input data describing the coverage and outcomes of an intervention, including how the distribution of condom use has changed as a result of the intervention.



- Overall number of sex workers at any point in time - the total average number of sex workers in the city, town or village being considered.

- Total number of sex workers targeted - the number of sex workers targeted by the intervention. This may be the same size as the overall sex worker population, or may be smaller if the intervention is only working, for example, in a small number of suburbs within a large city.

- Proportion sex workers targeted reached in the last 3 months – the proportion of sex workers targeted that have had recent contact with the intervention (eg, in the last three months). The emphasis on recent contact with the intervention has been adopted due to evidence suggesting that behavioural change (such as increased condom use) is associated with recent intervention contact.

- Proportion sex workers reached using STD services – proportion of sex workers reached by the intervention who are able to access intervention related STD treatment services.

- Average proportion of STDs treated effectively cured – proportion of STD infections treated

by intervention related STD treatment services that are effectively cured. The value will depend on the common forms of STD, and the extent to which they can be identified and cured. For example, high quality services may identify and cure 90% of STDs, poor quality services 20% of STDs.

- Proportion reporting using condoms:

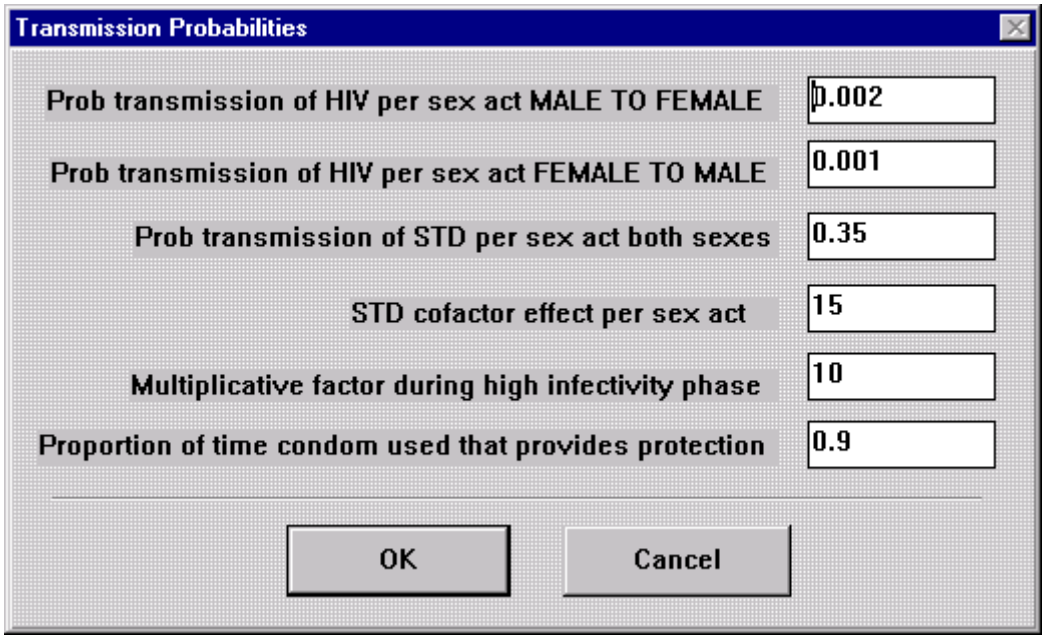
a) Never - Proportion of sex workers reporting not using condoms 'before' and 'after' the intervention.

b) Half of the time - Proportion of sex workers reporting using condoms half of the time before and after the intervention.

c) All of the time - Proportion of sex workers reporting using condoms all of the time before and after the intervention.

In each case, the 'before' figure may come from baseline behavioural information collected at the start of the intervention, or from sex workers who have not had contact with the intervention. The 'after' figure should come from behavioural evaluation data collected from sex-workers who have had recent contact with the intervention.

4.5 Transmission probabilities - change HIV and STD transmission probabilities, the cofactor effect of STD infection, and the initial cofactor effect during the high viraemia of an HIV infection.



- Prob transmission of HIV per sex act MALE TO FEMALE - Probability of transmission of HIV infection per sex act from males to females, in the absence of STDs, and/or high viraemia, when a condom is not used.

- Prob transmission HIV infection per sex act FEMALE TO MALE - Probability of transmission of HIV infection per sex act from females to males, in the absence of STDs, and/or high viraemia, when a condom is not used.

- Prob transmission of STD per sex act both sexes - Probability of transmission of STD infection per sex act for both sexes, when a condom is not used.

- STD cofactor effect per sex act - A multiplicative factor describing the extent to which the probability that HIV is transmitted is enhanced by either partner being infected with an STD per sex act. In practice, the value used can be taken to reflect the extent to which different forms of ulcerative and non-ulcerative STDs are common. Debate about the likely magnitude of the cofactor for different STDs is ongoing. In general though, a cofactor of 25-40 may be appropriate for settings where ulcerative STDs alone predominate, 15-25 in settings where both ulcerative and non-ulcerative STDs are common, and 5-

15 in settings where non-ulcerative STDs predominate.

- Multiplicative factor during high infectivity phase - A multiplicative factor describing the extent to which the per sex act probability of HIV transmission is higher during the initial high viraemia phase of HIV infection.

- Proportion of time condom used that provides protection - A factor describing the extent to which the use of a condom reduces the per sex act probability of either HIV or STD transmission. The value used may differ between settings, and be chosen to reflect factors such as the quality of the condoms available, the degree to which condoms are used by people when drunk, or the degree to which instructions on condom use are provided. A factor of between 0.9-0.95 may be appropriate for settings where good quality condoms are used well, 0.7-0.9 for setting where good quality condoms are used by people when drunk, and 0.5-0.7 in settings where condoms are of poor quality, or reported levels of condom breakage are high.

5. Model outputs

The output of the model is produced when the [CALCULATE] option is chosen from the [RESULTS] menu. The output of *SexWork 3.0* can be viewed in a number of different formats as listed under the [VIEW] menu heading. These are described in turn below (also see *Section 3.4*).

5.1 Data outputs

Shows the main data outputs for each month in a tabular format. The table is shown using a program called '*CellViewer*' that is automatically opened once the [DATA OUTPUT] option within the [VIEW] menu is selected. The table has the following headings:

Step	Time since start of intervention (months)
bprevSW	Projected HIV prevalence among sex workers in the absence of the intervention
bprevCL	Projected HIV prevalence among clients in the absence of the intervention
prevSW	Projected HIV prevalence among sex workers in the presence of the intervention
prevCL	Projected HIV prevalence among clients in the presence of the intervention
SW avert	Cumulative HIV infections averted among sex workers as a result of the intervention
CL avert	Cumulative HIV infections averted among clients as a result of the intervention

Within *CellViewer*, there is one menu heading [FILE]. The options within [FILE] can be used to save the data in a text file, print the data, or exit *CellViewer* and return to the main menu. Each of the menu options within [FILE] are described below, and can be selected using the mouse; using the down arrow key to move the highlighted bar down to the option required and pressing [Enter]; or by pressing the [Alt] key and the appropriately lettered key together.

File¦Save as... - Saves data as a text file, with the extension NAME.txt.

File¦Print - Prints the data file

File¦About - Gives more information about *CellViewer* - this has not been developed.

File¦Exit - Exits *CellViewer* and the data output screen, returning the user to the main *SexWork 3.0* menu.

5.2 Graphs

The model output can be viewed in five different graphical forms, described below. For each graph, the horizontal axis shows the timescale in months over which the calculations were made. The plots can be used to view a range of temporal trends in HIV prevalence HIV incidence and STD prevalence.

Each of the graphs is viewed using a program called *PlotView*, which is automatically opened once the [GRAPHS] option within the [VIEW] menu is selected. Within *PlotView*, there are two menu options: [FILE] and [VIEW]. The [FILE] menu can be used to rescale and print the graphs, and to exit *PlotView* and return to the main *SexWork 3.0* menu.

Within *PlotView*, the [FILE] menu has the following options:

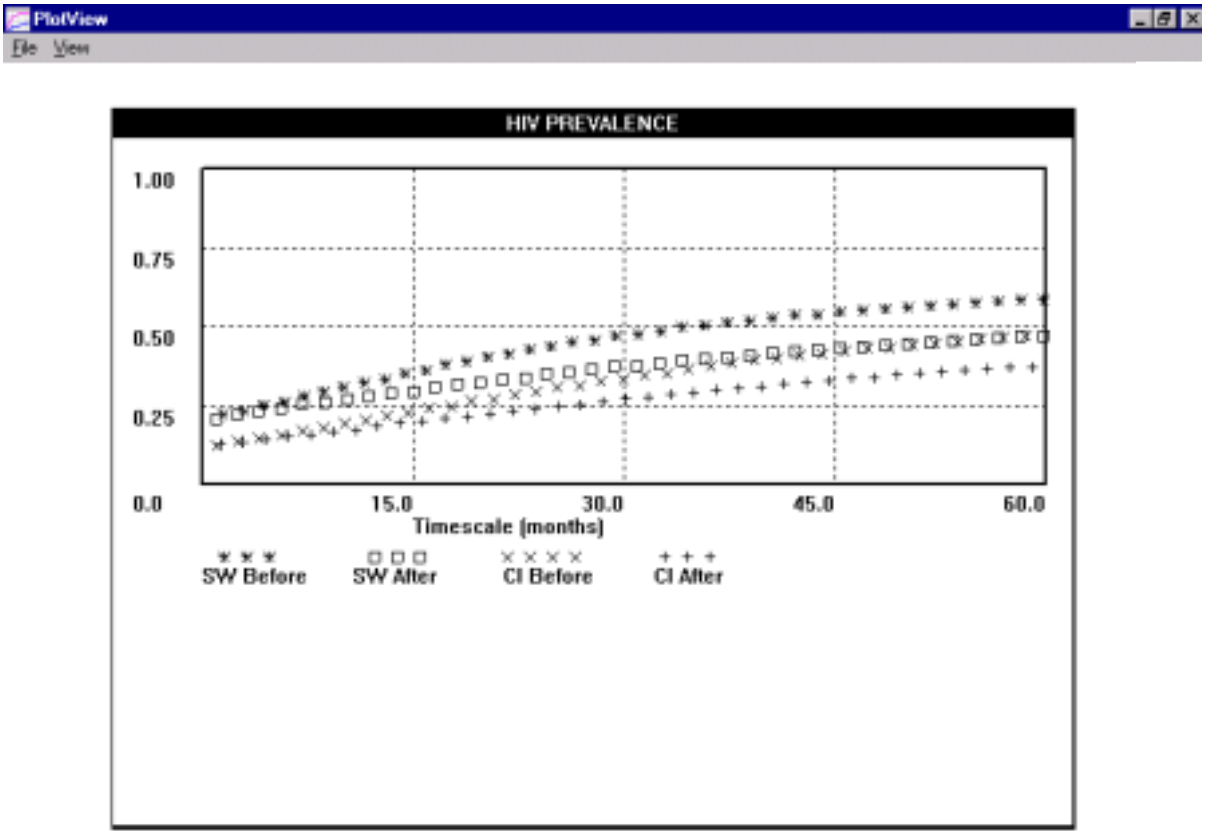
File¦Maximum Y – Enables the user to rescale the plots shown by defining the maximum value for the vertical axis.

File¦Print - Prints the current plot.

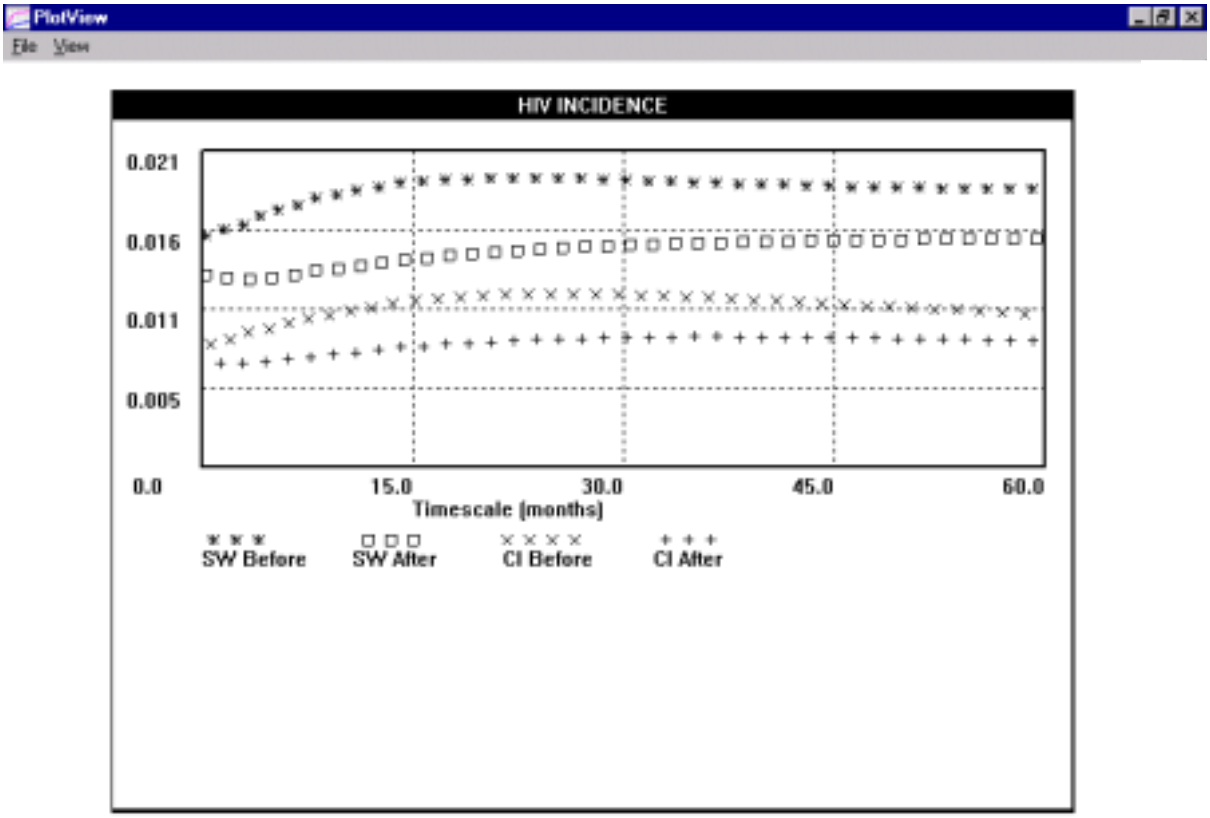
File¦Exit - Exits *PlotView*, returning the user to the main *SexWork 3.0* menu.

With *PlotView*, the [VIEW] menu can be used to select one of the pre-assigned plot formats for viewing. These are described in turn below:

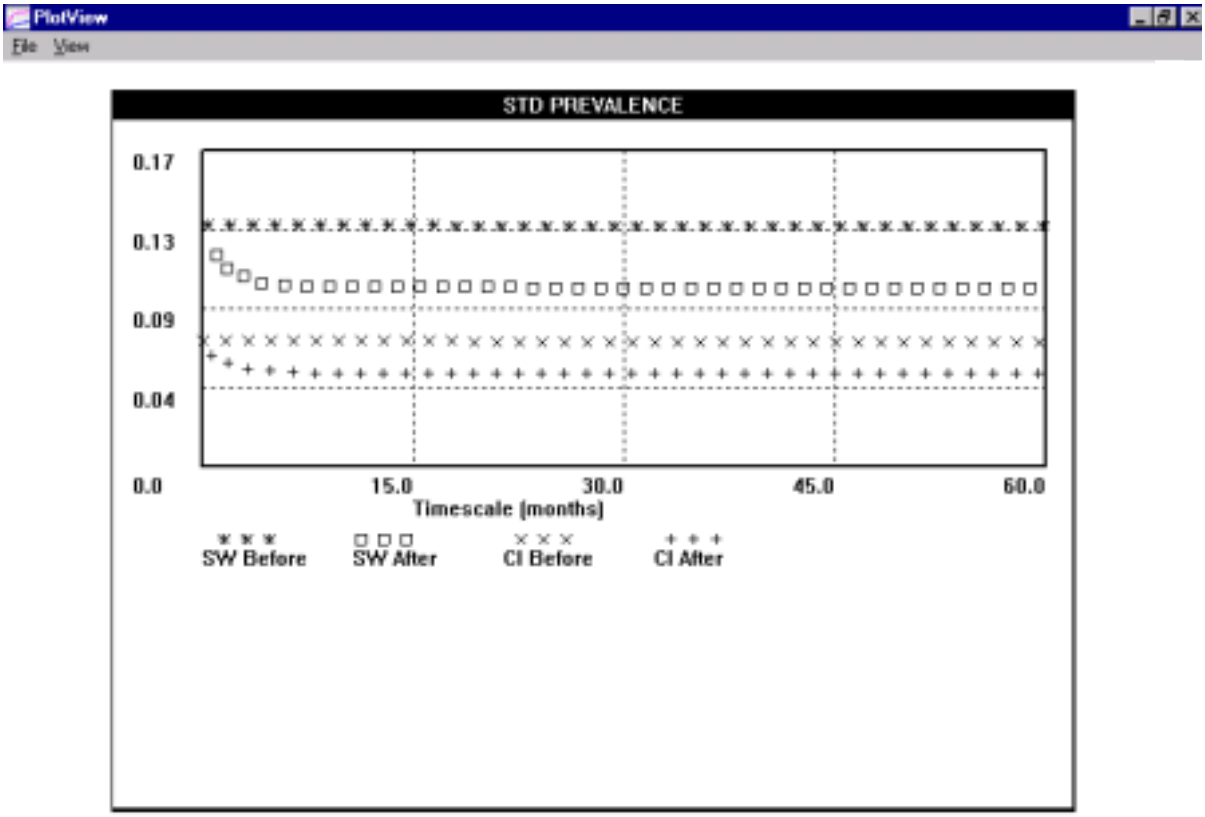
HIV PREVALENCE - plots a graph of the projected trends over time of HIV prevalence among sex workers and their clients. The graph shows the projected prevalence of HIV infection on the vertical axis for clients (Cl) and sex workers (SW) both in the presence (After) and absence (Before) of the sex worker intervention.



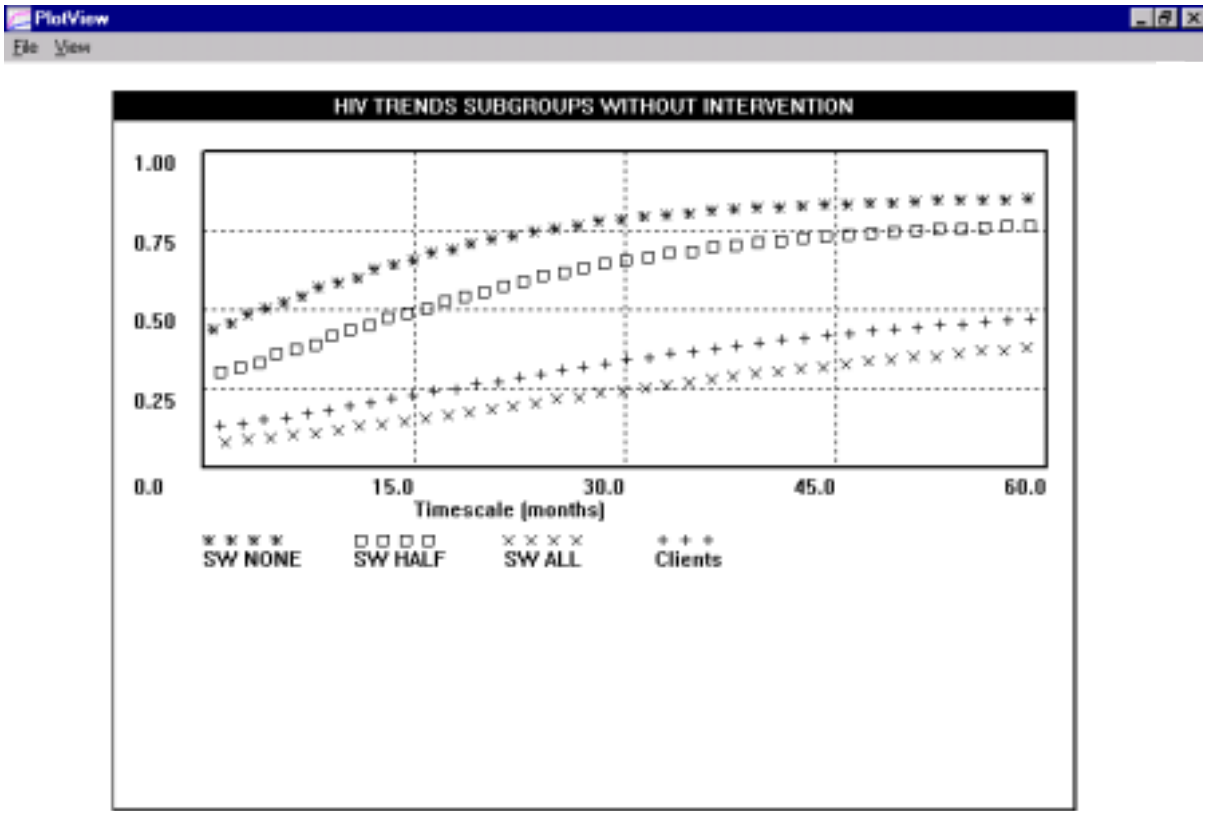
HIV INCIDENCE – plots a graph of projected trends over time of HIV incidence among sex workers and their clients. The graph shows the projected incidence of HIV infection on the vertical axis for clients (Cl) and sex workers (SW) both in the presence (After) and absence (Before) of the sex worker intervention. The vertical axis is automatically scaled to an appropriate value.



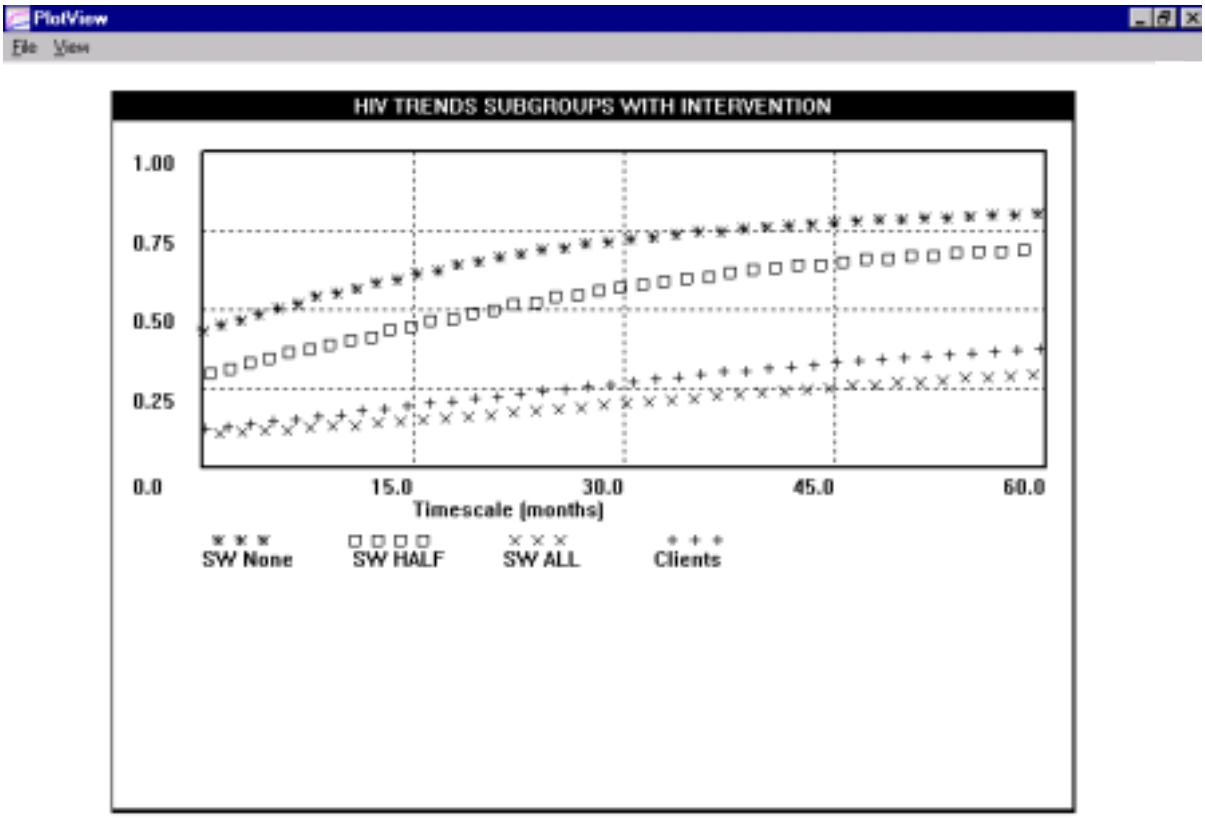
STD PREVALENCE - plots a graph of projected trends over time of STD prevalence among sex workers and their clients. The graph shows the projected prevalence of STD infection, on the vertical axis, for clients (Cl) and sex workers (SW) both in the presence (After) and absence (Before) of the sex worker intervention. The vertical axis is automatically scaled to an appropriate value.



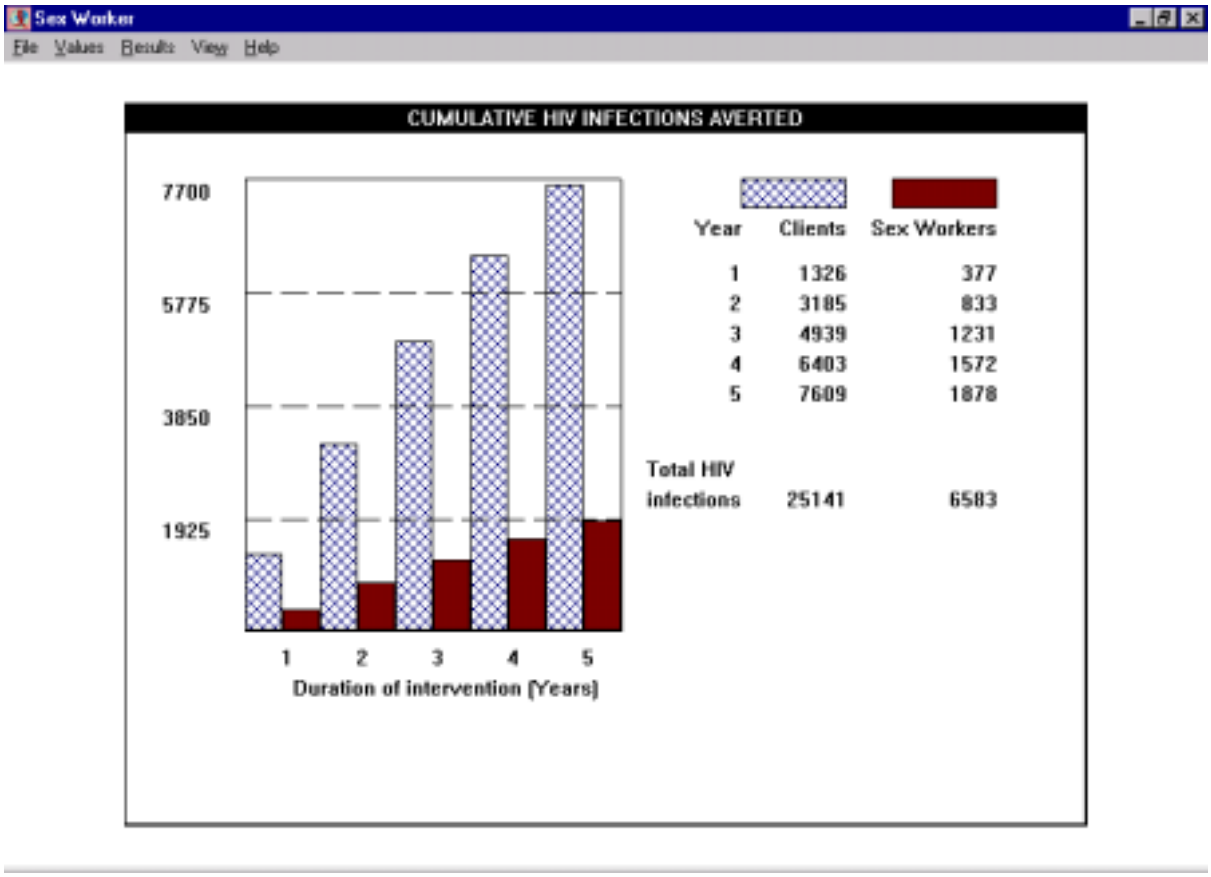
HIV TRENDS SUBGROUPS WITHOUT INTERVENTION – plots a graph of projected trends over time of HIV prevalence among sex workers and their clients in the absence of the sex worker intervention. The graph shows, on the vertical axis, the projected prevalence of HIV infection among clients (CL) and sex workers with different levels of consistency of condom use (SW NONE, SW HALF, SW ALL) in the absence of the intervention.



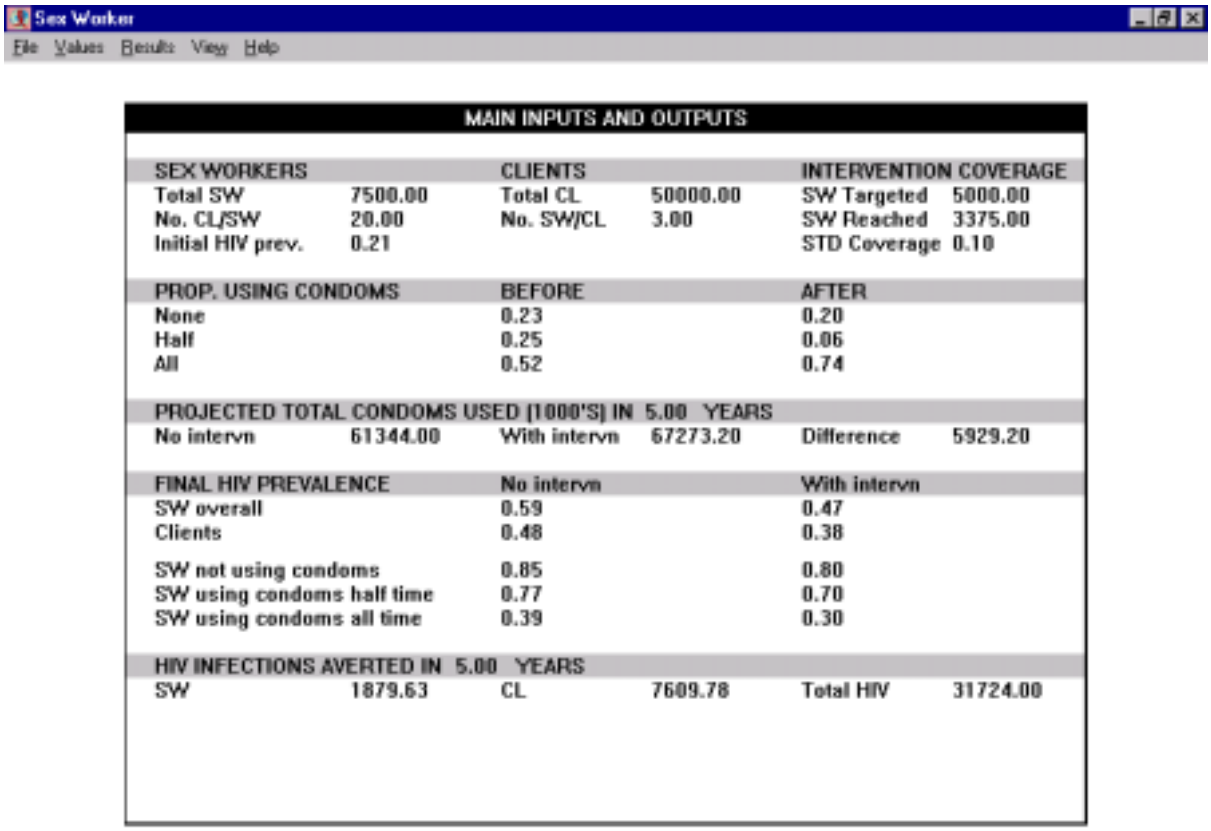
HIV TRENDS SUBGROUPS WITH INTERVENTION – plots a graph of projected trends over time of HIV prevalence among sex workers and their clients in the presence of the sex worker intervention. The graph shows, on the vertical axis, the projected prevalence of HIV infection among clients (CL) and sex workers with different levels of consistency of condom use (SW NONE, SW HALF, SW ALL) in the presence of the intervention.



INFECTIONS AVERTED - plots a bar graph of the projected cumulative number of HIV infections averted among sex workers and their clients due to the intervention. The graph shows the estimated cumulative number of HIV infections averted on the vertical axis for sex workers (solid dark bars) and their clients (shaded bars), for each year of the intervention (horizontal axis). The corresponding figures for each year are shown in the accompanying table. The projected number of HIV infections occurring among sex workers and their clients over the timeframe being considered is also shown.



SUMMARY SHEET - shows an outline of the main inputs, estimated values and outputs of the model. These are described below.



INPUTS

The inputs displayed give an overview of the sex worker population, the client population, and the coverage of the intervention among the overall sex worker population

Total SW	Input size of overall sex worker population
No. CL/SW	Input average number of clients per sex worker per month
Initial HIV prev.	Input initial HIV prevalence among sex workers at the start of the intervention.
Total CL	Estimated size of client population
No. SW/CL	Input average number of sex workers seen per client per month
SW Targeted	Input total number of sex workers targeted by the intervention

SW Reached — Estimated total number of sex workers recently reached by the intervention

STD Coverage — Estimated proportion of all sex workers able to access intervention related STD treatment services

PROP. USING CONDOMS - Input distributions of sex workers using condoms 'none', 'half' and 'all of the time' among sex workers not having contact with the intervention (BEFORE), and sex workers who have had recent contact with the intervention (AFTER).

OUTPUTS

The outputs displayed give an over-view of how it is estimated that the intervention has increased overall levels of condom use, reduced the prevalence of HIV infection among different sub-groups, and averted HIV infection. The three main headings are:

PROJECTED TOTAL CONDOMS USED (1000's) IN 'TIMEFRAME' YEARS - Uses information on the reported distribution of condom use, in the presence and absence of the intervention, to estimate the total number of condoms that would be used by sex workers and their clients (in 1000s) over the timeframe being considered, with and without the intervention. These are used to provide an estimate of the number of condoms used that may be attributable to the intervention. In some cases, it may be possible to compare this figure with records of the numbers of condoms distributed by the intervention.

FINAL HIV PREVALENCE - Displays the projected HIV prevalence at the end of the timeframe being considered in the presence and absence of the intervention, among specific sub-groups. Estimates are given 1) for the overall sex worker population, and the overall client population; and 2) among sex workers not using condoms, using condoms 'half of the time', and using condoms 'all of the time'.

HIV INFECTIONS AVERTED IN 'TIMEFRAME' YEARS - Displays the projected cumulative total number of HIV infections averted among sex workers (SW) and their clients (CL) over the timeframe being considered. The cumulative number of HIV infections that are projected to have occurred among both sex workers and their clients is also shown (Total HIV).

Appendix 1:

Summary of input parameters required by SexWork 3.0 and default values used

Data input type	Data inputs	Default value
Epidemiological inputs	Initial HIV prevalence in the sex worker population	0.21
	Average STI duration for sex workers (months) †	0.5
	Average STI duration for clients (months) ‡	0.5
	Average duration of initial high viraemia phase (months)	1.5
	Average duration between HIV infection and severe morbidity (months)	84
Transmission probabilities	Probability of HIV transmission per sex act for male to female §	0.002
	Probability of HIV transmission per sex act for female to male **	0.001
	Probability of STI transmission per sex act both sexes ††	0.35
	Average STI cofactor per sex act ‡‡	30
	Sexual transmission multiplicative factor to transmission rate during high viraemia phase §§	10
	Condom efficacy per sex act	0.9

† Average STI duration for sex workers, this is dependent on the local health services
‡ Average STI duration for clients, this is dependent on the local health services
§ HIV transmission rate for male to female, see refs. European study group 1992.
** HIV transmission rate for female to male, see refs. Haverkos *et al.* 1992 and Padion *et al.* 1991
†† STI transmission rate, see refs. Hook & Marra 1992, Hethcote & York 1984, Over & Piot 1996
‡‡ STI cofactor for HIV transmission, see refs. Laga *et al.* 1993, Hayes *et al.* 1995, Cameron *et al.* 1989, Plummer *et al.* 1991
§§ High viraemia cofactor for HIV transmission, see refs. Cohen *et al.* 1997, Pinkerton & Abramson 1996, Jacquez *et al.* 1994

Data input type	Data inputs		Default value
Intervention coverage and impact	Overall number of sex workers at any point in time		7500
	Total number of sex workers targeted		5000
	Proportion of sex workers targeted that are reached in last 3 months		0.675
	Proportion of sex workers reached using STD services		0.1
	Average proportion of STD's treated that are effectively cure		0.25
	Distribution of condom use amongst sex workers before the intervention	NONE	0.23
		HALF	0.25
		ALL	0.52
	Distribution of condom use amongst sex workers after the intervention	NONE	0.2
		HALF	0.06
		ALL	0.74
Behavioural inputs	Average timespan women sell sex (months)		60
	Average timespan men buy sex (months)		240
	Average number of clients per month per sex worker		20
	Average number of sex acts between client and sex worker		2
	Average number of sex workers seen by clients per month		3
	Definition of 'NONE' and 'HALF' and 'ALL' consistency of condom use for sex workers	NONE	0
		HALF	0.4
		ALL	0.9

References

European Study Group on Heterosexual Transmission of HIV. 1992. Comparison of female to male and male to female transmission of HIV in 563 stable *couples. British Medical Journal* 304: 809-813.

Haverkos, H.W., Battjes, R.J. 1992**.** Female to male transmission of *HIV*. *Journal of the American Medical Association* 268 (14): 1855-56.

Padian, N.S., Shiboski, S.C., Jewell, N.P. 1991. Female-to-male transmission of human immunodeficiency virus. *Journal of the American Medical Association* 266 (12): 1664-67.

Hook, E., Marra, C. 1992. Acquired syphilis in adults. *New England Journal of Medicine* 326: 1060-69.

Hethcote, H.W., Yorke, J.A. 1984. Gonorrhea transmission dynamics and control. *Lecture notes in Biomathematics*, Springer Verlag, New York.

Over, M., Piot, P. 1996. Human immunodeficiency virus infection and other sexually transmitted diseases in developing countries: Public health importance and priorities fo4r resource allocation. *The Journal of Infectious diseases* 174(Suppl 2): S162-75.

Laga, M., Manoka, A., Kivuvu, M. et al. 1993. Non-ulcerative sexually transmitted diseases as risk factors for HIV-1 transmission in women: Results from a cohort study. *AIDS* 7(1): 95-102.

Hayes, R.J., Shulz, K.F., Plummer, F.A. 1995. The cofactor 3effect of genital ulcers on the per-exposure risk of HIV transmission in sub-Saharan Africa. *Journal of Tropical Medicine and Hygiene* 98: 1-8.

Cameron, D.W., Simonsen, J.N., D'Costa, I.J. et al. 1989. Female to male transmission of human immunodeficiency virus type 1: risk factors for seroconversion in men. *The Lancet* ii: 403-407

Plummer, F.A., Simonsen, J.N., Cameron, D.W. et al. 1991. Cofactors in male-female sexual transmission of HIV-1. *Journal of Infectious Diseases* 163: 223-239

Cohen, M.S., Hoffman, I.F., Royce, R.A. et al. 1997. Reduction of concentration of HIV-1 in semen after treatment of Urethritus: Implications for prevention of sexual transmission of HIV-1. *The Lancet* 349 (9069): 1868-73.

Pinkerton, S.D., Abramson, P.R. 1996. Implication of increased infectivity in early stage HIV infections. *Evaluation Review* 20(5): 516-40.

Jacquez, J.A., Koopman, J.S., Simon, C.P., Longini, I.M. 1994 Role of the primary infection in epidemics of HIV infection in gay cohorts. *AIDS* 7(11): 1169-84.

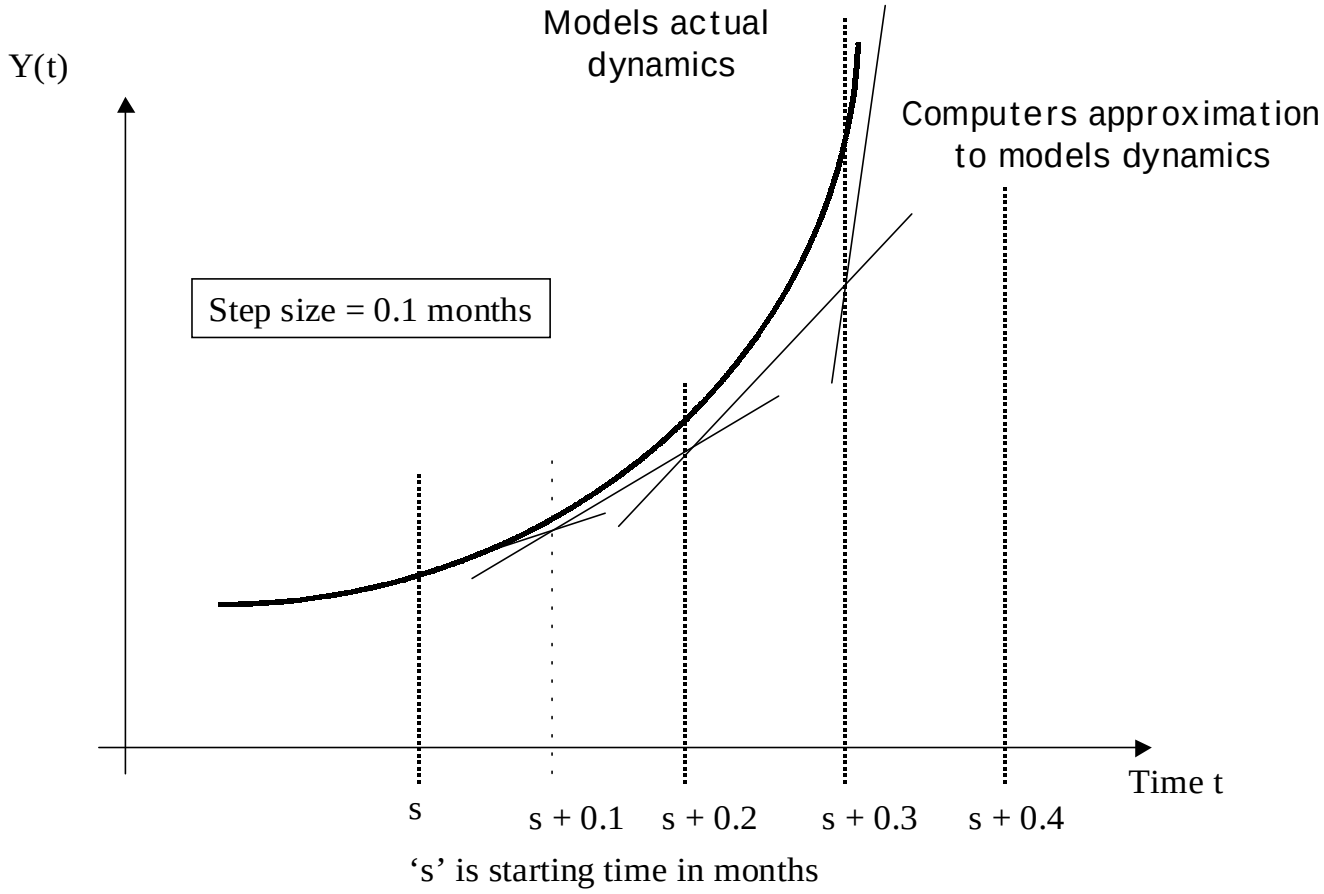
Appendix 2: Effect of step size on the computers numerical approximation to the models dynamics

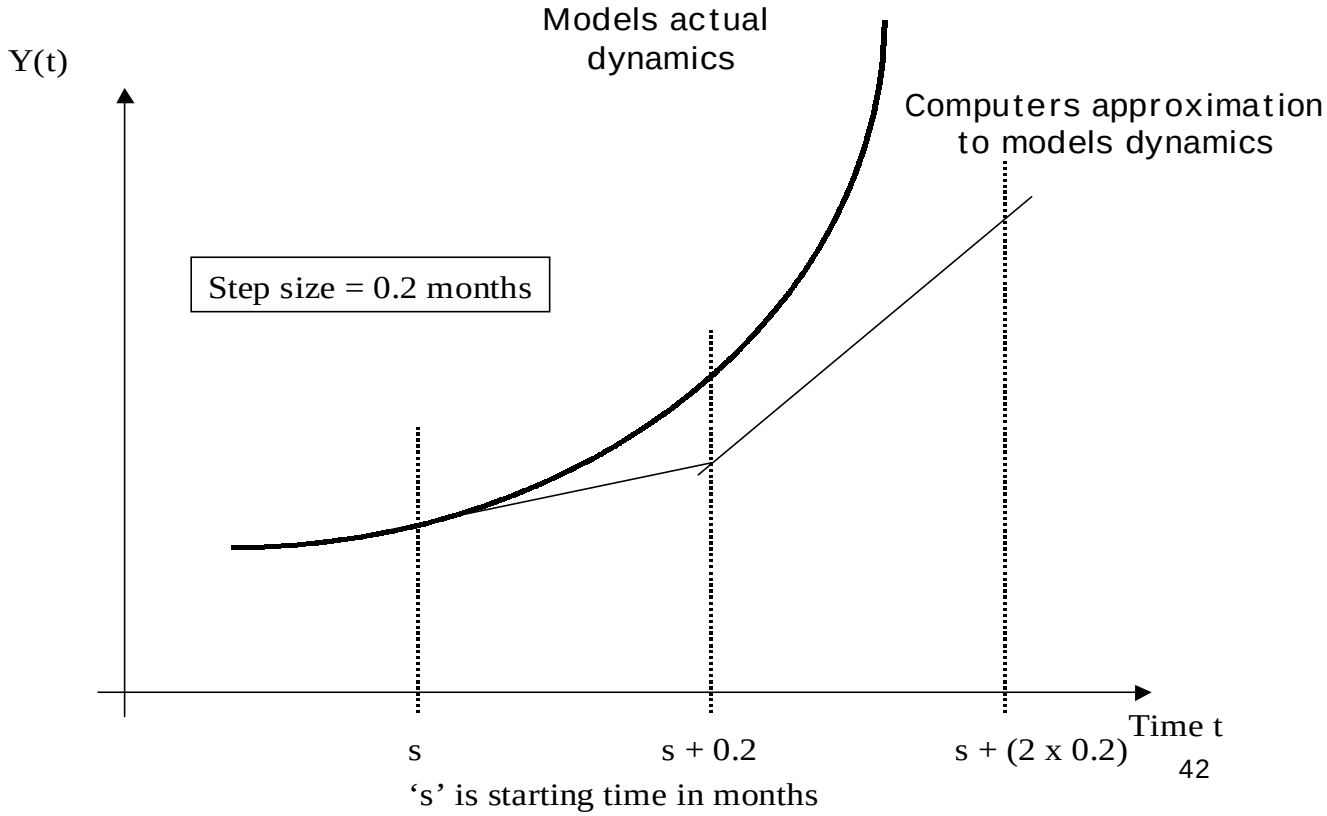
The model simulates the patterns of HIV and STI transmission between the groups targeted by the intervention and their sexual partners. Mathematically, the transmission process is described using methods from calculus. For this, a system of 'deterministic differential equations' are used to describe how, over time, we would expect HIV to be transmitted among the population. This is done by separating out the population being modelled into different sub-groups, according to their patterns of sexual behaviour and condom use (described using the behavioural input parameters), and according to their HIV infection status (either susceptible, infected with high viraemia, and infected with low viraemia). For each sub-group, the mathematical equations describe the rate of movement between the different HIV infection sub-groups, as those susceptible to HIV infection become infected, as those with high viraemia move into the low viraemia class, and as those with low viraemia become chronically sick and cease sexual activity. The rates of movement between these sub-groups are determined by the patterns of sexual behaviour and condom use, the distribution of STDs at that point in time, and the patterns of sexual contact between individuals in the different behavioural sub-groups.

These equations describe the slope of the prevalence functions among the different behavioural sub-groups over time. They can be solved to obtain prevalence estimates in each sub-group over time. However, it is not possible to solve these equations algebraically. Instead, numerical methods are used to approximate the solution to them. This is done in a step by step manner (as shown in Figure A1). Starting off with the initial levels of infection (at time s), the slope of each prevalence function is calculated using the differential equations. The prevalence value at the next point in time (say after 0.1 months) is estimated by using the value of the slope to draw a straight line through the initial prevalence value. This is used to approximate the true solution to the differential equation at the next point in time. The accuracy of this method of approximation depends on the size of the step size and the slope of the prevalence function. In general, the smaller the step size, the more accurate the solution. This can be seen by comparing Figures A1 and A2 below – which shows the true solution to the model, and the approximated solutions. In Figure 1 the step size is 0.1. In Figure A2 the step size is 0.2. As can be seen, as the step size is doubled from 0.1 to 0.2 months, the accuracy of the estimated solution decreases greatly.

Therefore, when using the model, it is important to try a range of step sizes, to ensure that the projected values are good approximations to the true solution to the model. The best way of doing this is outlined in the section headed 'step size'.

Figure A1.Estimating the solution to the model dynamics





Appendix 3: *HIVTools* models and publications

1. Currently Available from UNAIDS

- *SexWork*: Models the impact of interventions focused on sex workers and their clients.
- *Blood:* Models the impact of the strengthening of blood transfusion services.
- *School:* Models the impact of interventions focusing on youth in school.
- *IDU:* Models the impact of strategies to reduce HIV transmission among injecting drug users.
- *Costing Guidelines for HIV/AIDS Prevention Strategies*
- *Costing Guidelines for HIV/AIDS Prevention Strategies Among Injecting Drug Using Populations*.

2. Publications

Kumaranayake L, Pepperall J, Goodman H, and Mills A. (1998) *Costing Guidelines for HIV/AIDS Prevention Strategies.* UNAIDS Best Practice Collection - Key Materials.
http://www.unaids.org/highbrand/document/economics/index.html.

Kumaranayake, L. Mangtani P, Boupda-Kuate A, Foumena Abada JC, Cheta C, Njoumemi Z and Watts C. (1998) *Cost-Effectiveness of a HIV/AIDS Peer Education Programme Among Commercial Sex Workers: Results from Cameroon*. Presented at the XII World AIDS Conference, Geneva, 28 June - 3 July.

Mills A and Watts C. (1996). *Cost-effectiveness analysis of HIV prevention alternatives and the role of government*. Paper presented to the workshop >AIDS and development: the role of government=. Chateau de Limelette, Brussels, 17-19 June.

Watts C, Goodman H and Muyinda G. (1995) Estimation of the number of HIV infections averted by screening of blood. *The Lancet* 346: 783-4.

Watts C, Goodman H, Muyinda G, Msiska R, Mulenga D, Bertozzi S and Mills A. (1995) *Estimating the costs and impact of strengthening blood transfusion services in Zambia.* Abstract presented at the IXth International Conference on AIDS and STDs in Africa, Kampala, 10-14 December.

Watts CH. (1997) *Microbicides for HIV prevention: imperfect results and public policy*. Background paper for symposium on Practical and Ethical Dilemmas in the Clinical Testing of Microbicides. Women=s Health Advocates on Microbicides/The Population Council, Washington, USA.

Watts C and Kumaranayake L. (1999) Thinking big: scaling-up HIV-1 interventions in sub-Saharan Africa. *The Lancet* 354: 1492.

Kumaranayake L, Watts C. Moderating discussions on the web: opportunities, challenges and lessons learned Forthcoming *Health Policy and Planning*, March 2000.

Kumaranayake L, Watts C. *Costs of Scaling HIV Progam Activities to a National Level for Sub Saharan Africa: Methods and Estimates.* Forthcoming Washington, DC: World Bank.

Walker D, Vickerman P, Kumaranayake L et al. (1999). The importance of early intervention for HIV/AIDS prevention: The example of Belarus. Forthcoming *Mir Mediciny* (in Russian).

3. In progress

Watts C and Vickerman P. *SexWork*: new software to estimate the impact of interventions focused on sex workers on their clients.

Kumaranayake L, Watts C, Vickerman P *et al.* Replication and costs of replicating interventions in Cameroon.

Watts C, Vickerman P, Vaughan P *et al.* What matters?: key factors influencing the impact of interventions focused on sex workers and their clients.

Vickerman P and Watts C. *IDU*: a user-friendly model to estimate the impact of HIV interventions among injecting drug users.

Kumaranayake L, Vickerman P, Walker D *et al*: The cost-effectiveness of HIV preventive measures among injecting drug users in Svetlogorsk, Belarus.

Kumaranayake L, Walker D, Dickun et al. Harm reduction activities among injecting drug users in Belarus: a cost analysis.

Vickerman P and Watts C. HIV education for youth in school: a tool (SCHOOL) to model intervention impact.

Watts C, Kumaranayake L, Vickerman P *et al.* The cost-effectiveness of HIV interventions in sub-Saharan Africa for youth in school.

Kumaranayake L *et al.* The costs of in and out of school HIV interventions in Cameroon.

Watts C, Goodman H, Kumaranayake L *et al.* Factors influencing the cost, impact and cost-effectiveness of initiatives to strengthen blood transfusion services.