

# MODELING THE EXPECTED SHORT-TERM DISTRIBUTION OF NEW HIV INFECTIONS BY MODES OF TRANSMISSION

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## ACKNOWLEDGEMENTS

The initial spreadsheet was developed by the UNAIDS Reference Group on HIV Estimates, Modelling and Projections in 2002, and was revised and prepared for country application by UNAIDS in 2005. The model was updated by UNAIDS in 2011 to include the impact of antiretroviral therapy and to incorporate uncertainty analysis. The method for conducting uncertainty analysis was developed by the Futures Institute in 2009.

The model is based on formulae of Weinstein et al and employed in the model Avert.

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## SUMMARY

The “Modes of Transmission” model (MoT) is a simple mathematical model that was first developed by the UNAIDS Reference Group on Estimates, Modelling and Projections<sup>1</sup> to help countries estimate the proportion of new HIV infections that occur through key transmission modes using basic epidemiological and behavioural data as input. Initial application of the model<sup>1, 2</sup> illustrated the variation in patterns of new infections between countries and argued that this type of in-country application could be used to inform the planning of appropriately targeted responses.

Application of the model has since been recommended as part of the “Know your Epidemic / Know your Response” (KYE/KYR) initiative by UNAIDS, which aims to help countries become more systematic in their approach to prevention, i.e., using strategic information to make evidence-informed decisions related to planning appropriate responses to the HIV epidemic.

The first step in the proposed KYE/KYR process involves a comprehensive review of available epidemiological data to examine patterns and trends in the general and high risk populations and to describe associated behaviours and other risk factors.<sup>i</sup> The results of this review are then utilized in the second step to model the HIV incidence by mode of transmission through application of the MoT model. The third step involves a review of the current prevention response and resource allocation to determine the degree of alignment between the distribution of new infections by mode of transmission and resource allocation. Finally, this information can be used by policy makers to more effectively plan the national prevention response.

## OBJECTIVES

The objective of the MoT spreadsheet model is to help countries calculate the expected number of new HIV infections over the coming year on the basis of a description of the current distribution of prevalent infections and patterns of risk within different populations. The model firstly allows the user to identify those risk groups among whom most of the new infections are likely to occur and secondly to use this information to plan and help focus appropriate intervention strategies.

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<sup>i</sup>An Epidemiology Review toolkit has been developed to help countries determine if relevant data are available and to assess the quality of the available data. The current recommendation is that availability and quality of data should first be assessed to determine if a country is ready and if data are adequate for application for the model. The tool and manual are available at [www.unaids.org](http://www.unaids.org)

## METHODS

The Modes of Transmission model uses

- the current prevalence of HIV infection,
- the numbers of individuals with particular exposures, and
- the rates of these exposures

to calculate the expected incidence of HIV infection over the coming year.

The user of the spreadsheet has to provide biological and behavioural surveillance data to inform the values in the cells for the spreadsheet. Some of these may be reasonably well estimated, whereas others may be poorly specified. Default estimates of transmission probability per contact are based on reviews of published literature, but can also be specified by the user.

The adult population can be divided into groups with different risks of acquiring HIV (see below). By estimating the size of these risk groups and their exposure to HIV infection (i.e. the extent of behaviours which allow for the transmission of HIV and the prevalence of HIV infection among their contacts) we can identify where most new HIV infections will occur.

The model is described in more detail in Appendix A.

## LIMITATIONS

The model uses crude groupings of the population according to their main exposure to HIV infection. The results are only as good as the data entered in the spreadsheet on the estimated sizes of the risk groups, the current prevalence of HIV and other sexually transmitted infections, and the average risk behaviours within these groups. Even with reliable estimates the model does not take account of the distribution of behaviours within the risk groups, the patterns of mixing by demographic, social, geographic and economic variables and the influence of specific sexually transmitted diseases. It should therefore not be used to generate accurate predictions without a full description of these many complexities. Nonetheless, it does allow the user to identify where most of the new HIV infections are likely to be found and the relative orders of magnitude of the incident infections possible within risk groups. Furthermore, it allows users to see the type of data required, even for crude predictions, and therefore to identify the data gaps and areas in need of further data collection. The coverage and focus of the interventions can also be explored and the benefits of both increased coverage and efficacy can be illustrated.

# OVERVIEW OF MODES OF TRANSMISSION SPREADSHEET

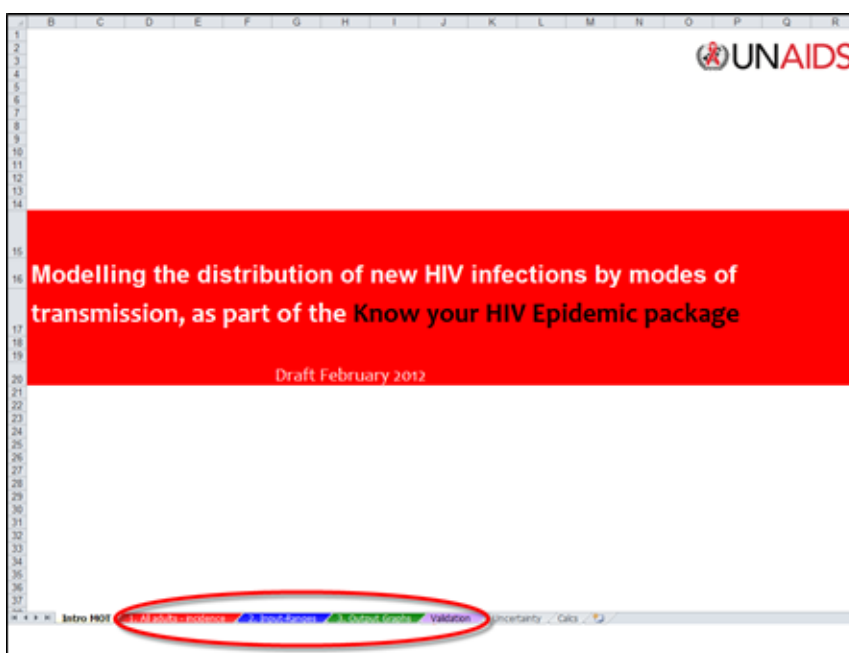
The MoT Excel spreadsheet consists of several worksheets, as shown in Figure 1:

1. **“All adults – incidence”**. This is the main page on which the Modes of Transmission analysis is performed and on which key data inputs need to be provided.
2. **“Input-Ranges”**. Uncertainty ranges on each of the input parameters are required on this page, which allows running the uncertainty analysis from this page.
3. **“Output Graphs”**. The final results (distribution of new infections by modes of transmission) with uncertainty bounds are displayed on this page.
4. **“Validation”**. If other sources of information on new HIV infections by modes of transmission are available, the results can be entered on this page as a way to compare or validate the MoT outputs.

## NOTE:

Because of the uncertainty associated with the input parameters, it is essential to always report MoT results with uncertainty bounds.

Figure 1. The MoT spreadsheet consists of different worksheets



## INSTRUCTIONS FOR MOT ANALYSIS

### Data required

The lay-out of the model is shown in Figure 2. User-specified inputs for the model are required for the cells with a light blue background and are optional for the cells that are colored light orange. The cells with a dark orange background are program outputs and contain formulae so the contents of these cells should not be changed.

Application of the model starts with providing the adult (aged 15-49 years) population size (cell C8), the estimated HIV prevalence (Cell D8) and an estimated range in which the adult incidence is expected to fall. This information can typically be obtained from the latest national estimation round (e.g. using the Spectrum software).

The model categorizes the adult population aged 15-49 years into groups according to their main source of exposure to HIV. Children are not included in this spreadsheet.

The risk groups are defined as:

- Row 15 Injecting drug users (IDU): adults (men and women) who are currently injecting, or have in the past 12 months injected drugs
- Row 16 The regular sex partners of those who inject drugs
- Row 17 Female sex workers (FSW): adult women who have exchanged sex for money in the last 12 month
- Row 18 Clients of female sex workers: adult men who have paid for sex with a sex worker in the last 12 months
- Row 19 The regular, non-commercial, sex partners of clients of sex workers
- Row 20 Men who have sex with men (MSM): adult men who have had sex with another man in the last 12 months
- Row 21 The regular female sex partners of those MSM who also have sex with women
- Row 22 Casual heterosexual sex (CHS): Those adults (men and women) who have had more than one sexual partner in the last 12 months

- Row 23 The regular, spousal or cohabiting, sex partners of those who engage in casual heterosexual sex
- Row 24 Stable heterosexual couples: Those adults who are currently in stable heterosexual relationships, i.e., adults with current low-risk behaviour (including those with former high-risk behaviour)
- Row 25 No risk: Adults who have been at no risk of acquiring HIV in the last year, i.e., those who do not inject drugs and are not currently involved in any sexual activity.
- Row 26 Medical injections: Adults who have received at least one medical injection in the last 12 months. In the absence of data it can be assumed to include the total adult population.
- Row 27 Blood transfusion: Adults who received a blood transfusion in the last 12 months

Figure 2. Spreadsheet for estimating incidence of HIV infection by modes of transmission.

For each risk group a number of variables are required, as shown in Figure 2 (columns C to N) and discussed below. Examples of potential data sources to inform these variables are provided in Appendix A (Table A1).



## 1. SIZE OF RISK POPULATIONS

**Definition:** The number of people who engage in the specific risk behaviours and for whom this is the main source of HIV infection risk. Note that people can only be counted in one of the risk groups (with the exception of medical injections and blood transfusions), even though they may have several different means of exposure. In the case of overlapping risk behaviours, people should be placed in the category where they are at highest risk (for example FSW who also inject drugs should be counted in the IDU category as the risk of infection through injecting drugs is higher than through sex work). Note that the “medical injections” and “blood transfusions” groups are counted independently.

- To be provided in cells C15 to F27
- Either the percentage of males and females with a certain risk behaviour (cells C15 to D27) or the absolute numbers of males and females with a certain risk behaviour (cells E15 to F27) need to be filled in. This information will be used to calculate the total number of adults with a certain risk behaviour, given in cells G15 to G27.
- The ‘risk groups’ are defined according to the main source of exposure to HIV. For medical injections, if data are not available, it can be assumed that the entire adult population is “exposed”.
- If a particular risk group does not apply to the adult population then its size can be set to zero.
- Note that the sum of all adults across risk groups (cell G28) should be equal to the total adult population in the country (specified in cell C8).
- Potential data sources for obtaining the number or percentage of people with certain risk behaviours are summarized in table A1.

## 2. CURRENT ESTIMATED HIV PREVALENCE BY RISK POPULATION

**Definition:** The percentage of people in the particular risk group who are infected with HIV.

- To be provided in cells H15 to H27
- If a risk group does not apply to the adult population then its HIV prevalence can be set to zero.

- Check that the total population HIV prevalence (cell H28) is similar to the national adult prevalence specified in cell D8 – if it is significantly different then the cell will be highlighted in green and the HIV prevalence for one or more of the risk populations will have to be adjusted. (The adult prevalence in H28 is the weighted average of the prevalences across the risk groups).
- The number of HIV infections is calculated from the prevalence estimates and are shown in cells I15 to I27. This information can be used to cross-check the prevalence data against other or known data sources.

### **3. PREVALENCE OF SEXUALLY-TRANSMITTED INFECTIONS (STI) BY RISK POPULATION**

*Definition:* The percentage of people in the particular risk groups who have a sexually transmitted infection.

- To be provided in cells J15 to J25
- Risk groups that do not require this information are partners of IDU, partners of sex-work clients, female partners of MSM, regular partners of those who have casual heterosexual sex, those who receive medical injections, and those who receive blood transfusions.

### **4. AVERAGE NUMBER OF PARTNERS PER YEAR IN EACH RISK POPULATION**

*Definition:* The average number of different partners (sexual or drug injecting) per year. Note that for medical injections each injection counts as having a “partner” and for blood transfusions, each donor counts as a “partner”.

- To be provided in cells K15 to K27
- For most risk groups, with the exception of IDU, medical injections and blood transfusions, this parameter requires the average number of sexual partners per year.
- For injecting drug users, this is the average number of needle-sharing partners per year.

- For medical injections and blood transfusions, this is the number of injections or transfusions received in the year of study: each one is counted as a ‘partner’.

## **5. AVERAGE NUMBER OF ACTS OF POTENTIAL HIV RISK EXPOSURES PER PARTNER PER YEAR**

*Definition:* The average number of contacts (injecting or sexual) with each partner per year.

- To be provided in cells L15 to L27
- For most risk groups, with the exception of IDU, medical injections and blood transfusions, the mode of HIV transmission is sexual, and the number of acts of exposure per partner per year is the average number of sex acts with each partner per year.
- For the IDU risk group, it is the average number of acts of needle sharing with each injecting partner per year.
- For medical injections and blood transfusions, the number of acts of exposure per ‘partner’ is fixed at one, because each blood transfusion or injection is regarded as having a new ‘partner’.

## **6. AVERAGE PERCENTAGE OF ACTS OF EXPOSURE THAT ARE PROTECTED**

*Definition:* The proportion of acts (sexual or injecting) that are protected by condom use or through the use of safe/sterile needles. For blood transfusions, the proportion of bloods that are screened for HIV is required.

- To be provided in cells M15 to M27
- For most risk groups, with the exception of IDU, medical injections and blood transfusions, the mode of HIV transmission is sexual, and the percentage of acts that are protected equals the percentage of sex acts in which condoms are used correctly. Remember that this percentage is the average over all partnerships.

- For the IDU risk group, it is the average percentage of injection events that involve safe/sterile needle use. Again, remember that this percentage represents the average over all partnerships.
- For the medical injections risk group, the percentage of acts of exposure that are 'protected' equals the proportion of injections that involve safe/sterile needle use.
- For the blood transfusions risk group, it is the percentage of units of blood that are screened effectively: this is the percentage of units that are tested, multiplied by the % sensitivity of the test used (i.e. the proportion of HIV+ blood units that are detected as being HIV+ and hence not used). Information on screening coverage collected through a WHO survey is provided in Appendix A (Table A2).

## 7. USE OF ANTIRETROVIRAL THERAPY

*Definition:* The number of HIV infected people who are receiving antiretroviral therapy (ART)

- To be provided in cells N8 (total), as well as N15 to N25 (by risk category)
- This information is used to adjust the transmission probability according to the level of ART coverage in the population. Recent studies have confirmed that the use of ART among HIV positive people can reduce HIV transmission to their negative heterosexual partners by about 96%.<sup>3</sup>
- The overall number of adults currently receiving antiretroviral therapy (ART) should be provided in cell N8
- The number of people receiving ART in each risk group should be provided in cells N15 to N25
- ART is assumed to reduce heterosexual transmission of HIV by 96% (cell O8), homosexual transmission by 90% (cell P8) and IDU transmission by 80% (cell Q8).

## 8. MALE CIRCUMCISION

**Definition:** The percentage of adult men in the population that are circumcised

- To be provided in cell L8
- This information is used to adjust the transmission probability according to the prevalence of male circumcision in the population. Three randomized controlled trials have confirmed that medical male circumcision provides some protection to men and reduces the transmission of HIV from females to males by 60%.<sup>4-6</sup>
- The percentage of men that are estimated to be circumcised can be entered into cell L8. The female to male transmission probability in cell H8 will be automatically adjusted according to the male circumcision rate.
- Until further data become available, it is assumed that male circumcision does not have a direct impact on male to female transmission.

## 9. TRANSMISSION PROBABILITY PER RISKY EXPOSURE ACT

**Definition:** The probability that HIV is transmitted during an act of exposure (sexual/injecting/medical). It provides a measure of HIV infectivity.

- Cells G8 to J8

***Default transmission probabilities, based on extensive literature reviews, are provided and it is recommended that these are used. However, the probability estimates can be changed if country specific data are available.***

- In this spreadsheet the transmission probability for each risk group represents the average infectivity of HIV+ partners to whom they are exposed. For example, the transmission probability for IDU represents HIV infectivity of sharing needles with other IDU, whilst the transmission probability for sexual partners of IDU represents HIV infectivity of sexual contact.

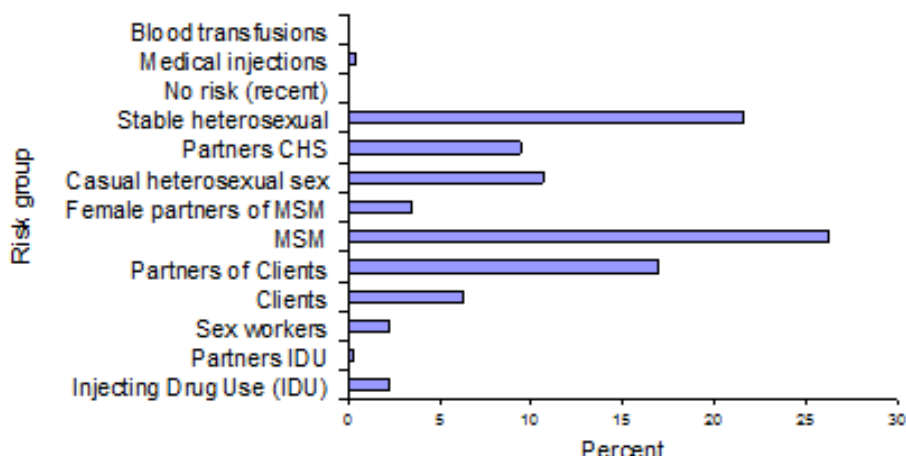
## **Effect of Sexually Transmitted Infections (STI) on HIV transmission**

- HIV+ individuals who are also infected with a sexually-transmitted infection (STI) are more likely to transmit HIV during sexual contact than HIV+ individuals who do not have an STI. A comprehensive review of the scientific literature suggest that the probability of transmission in the presence of an STI range between 2 and 23.5, with the majority clustering between 2 and 5.7 Here we assume that the STI cofactor is 4,8 as shown in cell K8.
- In the case of sexual transmission, there are two transmission probabilities estimated for each risk group: transmission in the presence and in the absence of STIs (for the IDU, blood transfusions and medical injections risk groups this is not relevant because HIV transmission is not sexual). Cells P16 to P24 contain the transmission probabilities for sexual transmission of HIV from HIV+ individuals who also have an STI, and cells Q16 to Q24 contain the transmission probabilities for transmission of HIV from HIV+ individuals who do not have an STI. These probabilities would also be adjusted for the potential impact of male circumcision and use of ART.
- Cell Q15 contains the transmission probability for HIV transmission among injecting drug users, adjusting for the impact of ART; cell Q26 contains the transmission probability for unsafe medical injections; and cell Q27 contains the transmission probability through blood transfusions (which is very high).

## EXAMINE THE RESULTING INCIDENCE PATTERN

- Cells R15 – T27
- The incidence, defined as the number of new HIV infections over one year in each risk population, is shown in cells R15 to R27, along with the total number of new adult infections in R29 and the total incidence among ‘partners’ (i.e. partners of IDU + partners of sex-work clients + female partners of MSM + regular partners of those who have casual heterosexual sex) in cell R30.
- Cells S15 to S27 and S30 show the percentage of the total incidence that occurs in each risk group.
- Finally and importantly, the incidence rate per 100,000 population is shown by risk population in cells T15 to T27 (and for the adult population overall in cell T29).
- The distribution of incidence by risk behaviour (cells S15-S27) is shown graphically in cells B31-I52 (Figure 3). Note however, this graph should only be used for examination of the incidence pattern. The final distribution of new infections should be presented with uncertainty bounds as discussed below.

Figure 3: Structure of the population for the MoT modeling



# UNCERTAINTY ANALYSIS

The reliability of the MoT model outputs is greatly affected by the level of uncertainty associated with the input data. Uncertainty can arise from different sources including the quality of the studies used to provide input data, variation in estimates between studies, power, representativeness and generalisability of study estimates, all of which are important criteria to rate the quality of the input data. In particular, studies on populations most at risk of HIV infection need to be interpreted carefully, as certain behaviours or HIV and STI prevalence from one study might not always be generalizable to the whole population. For example, street-based sex workers may have different risk behaviours compared to brothel-based sex workers, and rural and urban men who have sex with men may have different levels of HIV prevalence. Uncertainty can also be associated with insufficient data. In several countries high risk populations such as injecting drug users and men who have sex with men are stigmatised and hidden and therefore difficult to study. In such cases it is often necessary to extrapolate parameters from a single study, sometimes carried out in a neighbouring country.

To take these issues into consideration in the modes of transmission model, a component was developed to estimate the uncertainty around the model outputs, as described below.

## METHODS

In the uncertainty analysis, the specified model inputs are allowed to vary simultaneously and randomly within a set range of uncertainty for several model runs (typically 500-1000 runs). Each run will result in a different estimate of the number of incident cases per risk population and of total incidence. The range on the total adult incidence (aged 15-49 years) is typically obtained from the Spectrum software (used to obtain national estimates of HIV impact) and used to select plausible outputs: runs which give a total incidence outside these bounds are discarded. The median of all selected outputs is calculated and the uncertainty is described by plausibility bounds defined as the 2.5 and 97.5 percentiles.



## STEPS IN THE UNCERTAINTY ESTIMATION PROCESS

The uncertainty analysis can be run from the worksheet called “Input-ranges” as shown in Figure 4.

Figure 4. Uncertainty analysis page

Uncertainty analysis inputs						
3	Number of iterations	1000				
4	Transmission per act					
5	Male -> female	20%				
6	STD cofactor	20%				
7	Range of annual new infections					
8	Low	2,000				
9	High	8,000				
Uncertainty Ranges (Percent variation on input)						
	Adult Risk Behaviour	Total number with risk behaviour	Prevalence of HIV (%)	Prevalence of STI (%)	Number of partners per year	Number of acts of exposure per partner per year
13	Injecting Drug Use (IDU)	20%	50%	50%	50%	50%
14	Partners IDU	20%	50%			10%
15	Sex workers	20%	20%	20%	20%	10%
16	Clients	20%	20%	20%	20%	10%
17	Partners of Clients	20%	20%			10%
18	MSM	20%	20%	20%	20%	10%
19	Female partners of MSM	20%	20%			10%
20	Casual heterosexual sex	20%	20%	20%	20%	10%
21	Partners CHS	20%	20%			10%
22	Low-risk heterosexual	20%	20%	20%	20%	10%
23	No risk (recent)	20%	0%	0%		0%
24	Medical injections				10%	
25	Blood transfusions		10%			
<a href="#">Click here to run Uncertainty Analysis</a>						

### NOTE:

In order to run the uncertainty analysis, the user must be able to run macros from Excel.

## **STEP 1. Provide uncertainty/variation ranges on each of the input parameters**

For the majority of the parameters included in the model it will be difficult to provide or calculate confidence intervals. It is therefore suggested to provide a variation range in the form of a percentage attributed to each of the parameters depending on how reliable the parameter values are. The choice of this range is based on experts' opinions depending on the source, quantity and quality of available data and should be entered in the blue cells of the worksheet called "Input-ranges" as shown in *Figure 4*. The % variation should be no larger than 100%. A list of criteria to guide the user on how to define this range is available in Appendix B. For example, some parameters can be allowed to vary by 20% while others which are less reliable can have a 100% variation range. This should ensure the final results to reflect the potential contribution of each group when including extreme scenarios.

### *Restricting the outputs*

The number of simulated model runs required for the uncertainty analysis should also be entered in this worksheet (in cell B3). The recommended number of runs (and therefore the default option) to obtain sound results is 1000. However, only runs which give a number of new infections within the range obtained from the Spectrum outputs (cells B8 and B9, transferred from the "All adults-incidence" page) are included in the calculation so more runs are normally completed in order to obtain the specified number of runs required.

Other restrictions are directly imposed into the calculations (on the hidden worksheet called "Calcs"): the total male and female population is set to be equal to 100% by allowing the proportion of low risk individuals to vary according to the proportion of individuals in other groups. Similarly, the total population prevalence is set to be equal to the specified adult value by making the prevalence of the low risk group a function of the other parameters involved in this calculation. Also, in order to keep the number of partners times sex acts equal for FSW and clients, the number of clients' sex acts was set to be a function of the other parameters which determine the final result.

### **NOTE:**

The adult incidence range obtained from Spectrum is considered to be a reliable estimate and it is calculated using a different method, meaning that it can be regarded as an independent value and used as a validation criterion.

### *Model simulations*

A large number of possible combinations resulting from the simultaneous variation of all the parameters are sampled when the uncertainty analysis is conducted. Using the RANDOM function in Excel, the simulations are generated from the worksheet called “Calcs”. This worksheet is hidden since all the calculations are automatically performed when the uncertainty analysis is run, and the user does not have to make any changes on this page.

## **STEP 2. Running uncertainty analysis**

The uncertainty analysis can be run from the “Input-ranges” page by clicking on the red button called “Uncertainty analysis” (see Figure 4). This will start the process of generating the number of iterations that have been specified in cell B3.

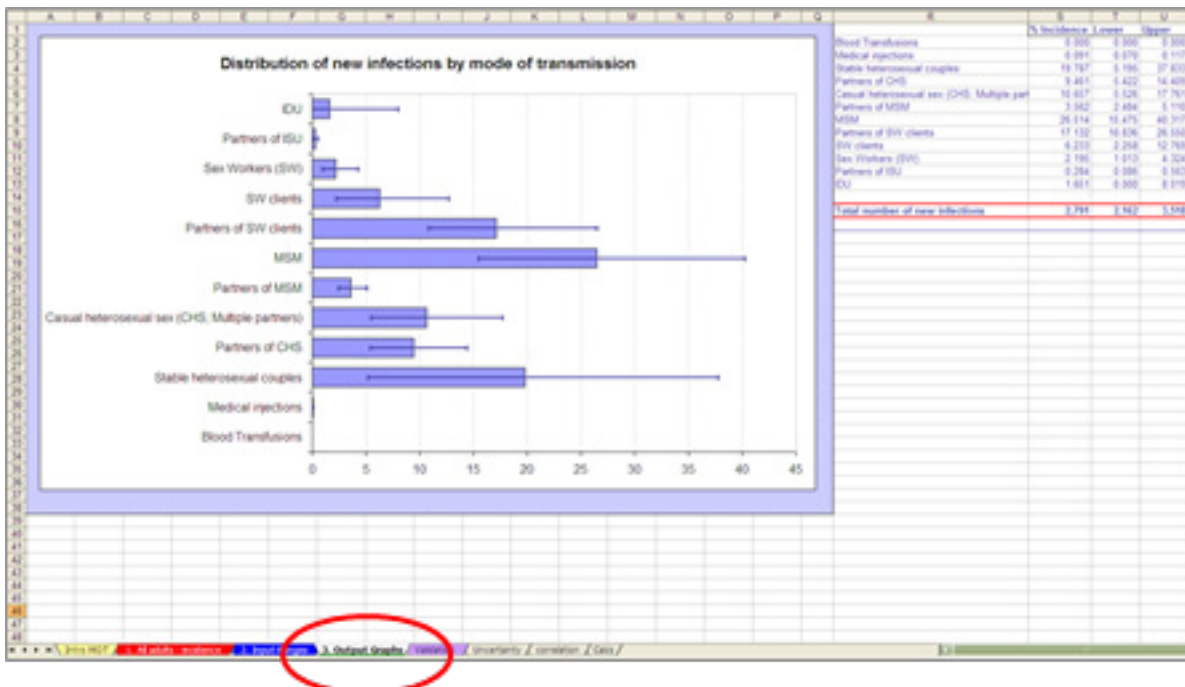
The summary statistics of the model runs (typically 1000 runs), including the median, 2.5 and 97.5 percentiles are calculated and will be shown as plausibility bounds for the final output, i.e. showing that 95% of all values for incidence calculated in each run fell in this range.

The individual outputs (percent of new infections by risk population) for each of the model runs are given in the hidden spreadsheet called “Uncertainty”. Unless the user is interested in the individual model runs, this spreadsheet is not normally used.

## **MODEL OUTPUTS WITH UNCERTAINTY RANGES**

The final results of the MoT model with uncertainty bounds are produced in the worksheet “Output graphs”, as shown in Figure 5, and can be used for formal publication of results.

Figure 5. Results of the uncertainty analysis, showing median and high and low bounds of the percentage of new infections attributed to each risk group in table and graph forms.



### STEP BY STEP SUMMARY OF UNCERTAINTY ANALYSIS

1. The base parameter values are taken from the model inputs on the “All adults-incidence” worksheet.
2. The low and high bounds on the total number of adult new infections are typically obtained from Spectrum. They can be entered in the “All adults-incidence” page and are automatically transferred to the “Input-ranges” page.
3. On the “Input-ranges” worksheet, enter the variation percentages for each of the input parameters.
4. Also on the “Input-ranges” worksheet, enter the number of model runs that are required (the default is set at 1000)
5. Run the Macro by clicking on the red button called “Uncertainty Analysis”.
6. Final model output with uncertainty bounds are provided in the “Output Graphs” worksheet.

## DISCUSSION

The purpose of this analysis is to see if the overall conclusions from applying the model are sensitive to the input values. For example, if the model results indicate that most new infections occur among stable heterosexual couples, we would like to know whether that conclusion would be different if the input values were somewhat different, but still within a plausible range. If the ranges around the percent of new infections by risk group overlap substantially then we need to be cautious in describing the source of most new infections. However, if the uncertainty ranges do not overlap it means that the conclusions are robust and not likely to be different if we have used different values.

### *Strengths and limitations*

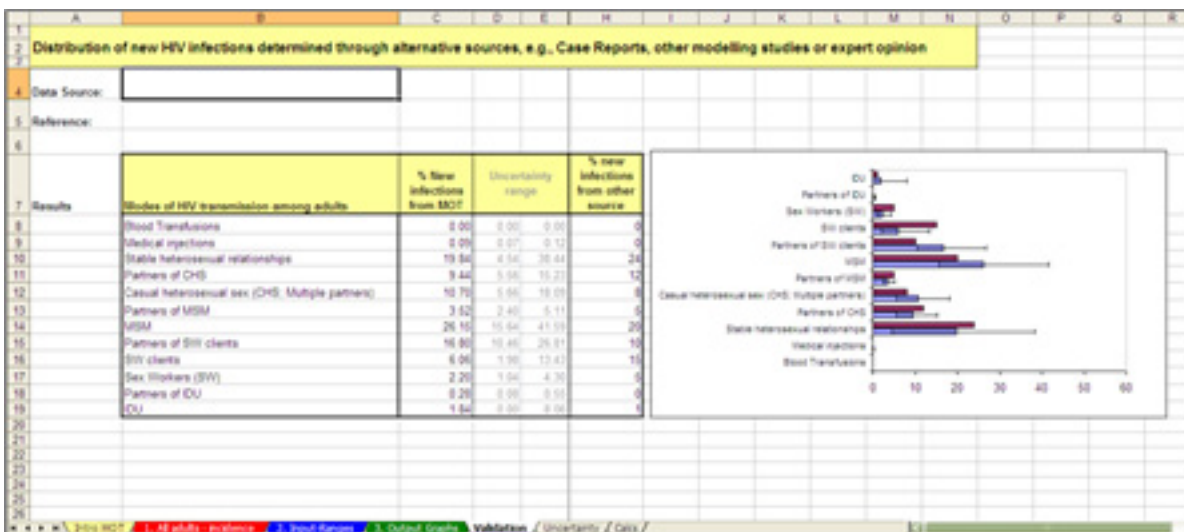
The advantage of this method is that it allows testing the extent by which the contribution of a risk group to the total HIV incidence changes when imposing very high uncertainty ranges on some parameters. This is useful when very little or no data is available for a specific a risk group and important assumptions have to be made. It is not computationally demanding and is easy to implement.

This method only takes into account uncertainty related to the input parameters and does not incorporate the uncertainty inherent to the model assumptions, meaning that it is likely to underestimate total uncertainty. In some instances the uncertainty on the input parameters might appear as a subjective choice. However, when this information is lacking or when parameters have to be extrapolated from sub-national or foreign studies, it is necessary to make assumptions. If these are based on sound criteria they should provide a reasonable reflection of the actual uncertainty of these values.

# VALIDATION OF MODEL OUTPUTS

If alternative sources of information are available on the distribution of new adult infections in a country, for example from other modeling exercises (eg. EPP/Spectrum, Asian Epidemic Model, other models), from good case notification systems, or from consensus expert opinion, the results can be compared with those of the MoT on the page called “Validation”, as shown in Figure 6. Note that the analysis on this page is optional and should only be done if other reliable sources of information on the distribution of new infections exist.

Figure 6. Validation page: Results from MoT can be compared to other sources of information on modes of HIV transmission, if available.



# APPENDIX A

## MODEL ASSUMPTIONS

If we assume that the risk of infection in a susceptible individual is a simple binomial function of their number of partners and number of sex acts with each partner we can derive a risk per susceptible which depends upon the current prevalence of infection within their contacts. We can further take account of the different transmission probabilities when another STI is or is not present. If we multiply this by the number of susceptibles at risk in the population we get an expected incidence for the coming year using the following equation:

$$I = S \left[ 1 - \left\{ p \left( B(1 - \beta'(1 - v))^a + (1 - B)(1 - \beta)^{a(1-v)} \right) + (1 - p) \right\}^n \right]$$

where I is the incidence of HIV in the target population, which depends upon the number susceptible, S, and the HIV prevalence in the partner population, p. The variable B is prevalence of STIs in the target or partner population, whichever is higher,  $\beta'$  and  $\beta$  represent the probability of transmission of HIV during a single contact in the presence or absence of an STI (in the case of transmission by needle-sharing  $\beta' = \beta$ ), v is the proportion of acts currently protected by effective condom use or the use of sterile needles, a is the number of contacts per partner and n is the number of partners (*Figure 2*).

## POTENTIAL SOURCES OF DATA

A summary of the data required for each risk group with potential sources of data are provided in Table A1.

Table A1: Data required and possible sources of information

Data required for each risk groups	Potential sources of data
Number (or percentage) of individuals in risk group	Surveillance (HIV, STI, Behavioural), Population based surveys (e.g., DHS, MICS), other published and unpublished reports/papers. In countries with DHS reports, data can be found in the chapter on "HIV/AIDS-related Knowledge, attitudes and behaviour"  Medical Injections : See Hutin et al.9  Blood transfusions: See table by Rapiti et al.10 below
HIV prevalence in risk group	HIV surveillance in various risk populations, Population based surveys, UNAIDS/WHO Epi Fact sheets, other published papers/reports.  In countries with DHS reports, data can be found in the chapter on "HIV Prevalence and associated factors"
Prevalence of STI	Surveillance (behavioural and biomedical) and special studies, population based surveys, other published papers/reports.  In countries with DHS reports, data on self-reporting of STIs can be found in the chapter on "HIV/AIDS-related Knowledge, attitudes and behaviour"
Average number of partners per year	Behavioural surveillance, population based surveys, published papers/reports In countries with DHS reports, data can be found in the chapter on "HIV/AIDS-related Knowledge, attitudes and behaviour"  Blood transfusions and Medical injections: Number received should be reported (usually 1 per year)
Number of acts per partner per year	Behavioural surveillance, population based surveys, published papers/reports.  In countries with DHS reports, data can be found in the chapter on "HIV/AIDS-related Knowledge, attitudes and behaviour"  Blood transfusions and Medical injections: Fixed at 1
Percentage of potential exposure acts protected	Behavioural surveillance, population based surveys, published papers/reports  Medical Injections : See Hutin et al.9  Blood transfusions: See tables below by Rapiti et al.10
Transmission probability per act of exposure with and without STIs	Recommended to use default values that are derived from published literature



## DATA ON SCREENING OF BLOOD TRANSFUSIONS (WHO)

Table A2. Estimated number of blood transfusions per person per year and proportion screened, by region for 2000

	AFR D	AFR E	AMR A	AMR B	AMR D	EMR B	EMR D	EUR A	EUR B	EUR C	SEAR B	SEAR D	WPR A	WPR B
<b>Proportion of screening HIV</b>	92.8%	96%	100%	92%	67%	100%	97%	100%	97.8%	100%	100%	74%	100%	94%
<b>Worse-case scenario</b>	50%	50%	100%	50%	50%	80%*	50%	100%	80%*	80%	50%	50%	100%	50%
<b>Published studies</b>	-	82.5% (72-93)	100%	95.9% (85-100)	81.8% (60-100)	-	52%	100%	-	-	-	-	100%	-
<b>Number of blood transfusions per 1000 persons and per year</b>	4	5	43	11	7	18	4	57	11	20	5	4	36	15

### Regions:

- AFR D:** Algeria, Angola, Benin, Burkina Faso, Cameroon, Cape Verde, Chad, Comoros, Equatorial Guinea, Gabon, Gambia, Ghana, Guinea-Bissau, Liberia, Madagascar, Mali, Mauritania, Mauritius, Niger, Nigeria, Sao Tome and Principe, Senegal, Seychelles, Sierra Leone, Togo
- 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
- AMR A:** Canada, Cuba, United States of America
- AMR B:** Antigua and Barbuda, Argentina, Bahamas, Barbados, Belize, Brazil, 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 the Grenadines, Suriname, Trinidad and Tobago, Uruguay, Venezuela
- AMR D:** Bolivia, Ecuador, Guatemala, Haiti, Nicaragua, Peru
- EMR B:** Bahrain, Cyprus, Iran (Islamic Republic of), Jordan, Kuwait, Lebanon, Libyan Arab Jamahiriya, Oman, Qatar, Saudi Arabia, Syrian Arab Republic, Tunisia, United Arab Emirates
- EMR D:** Afghanistan, Djibouti, Egypt, Iraq, Morocco, Pakistan, Somalia, Sudan, Yemen
- EUR A:** Andorra, Austria, Belgium, Croatia, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Israel, Italy, Luxembourg, Malta, Monaco, Netherlands, Norway, Portugal, San Marino, Slovenia, Spain, Sweden, Switzerland, United Kingdom
- EUR B:** Albania, Armenia, Azerbaijan, Bosnia and Herzegovina, Bulgaria, Georgia, Kyrgyzstan, Poland, Romania, Slovakia, Tajikistan, The Former Yugoslav Republic of Macedonia, Turkey, Turkmenistan, Uzbekistan,
- EUR C:** Belarus, Estonia, Hungary, Kazakhstan, Latvia, Lithuania, Republic of Moldova, Russian Federation, Ukraine
- SEAR B:** Indonesia, Sri Lanka, Thailand
- SEAR D:** Bangladesh, Bhutan, Democratic People's Republic of Korea, India, Maldives, Myanmar, Nepal
- WPR A:** Australia, Brunei Darussalam, Japan, New Zealand, Singapore
- 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, Solomon Islands, Tonga, Tuvalu, Vanuatu, Viet Nam

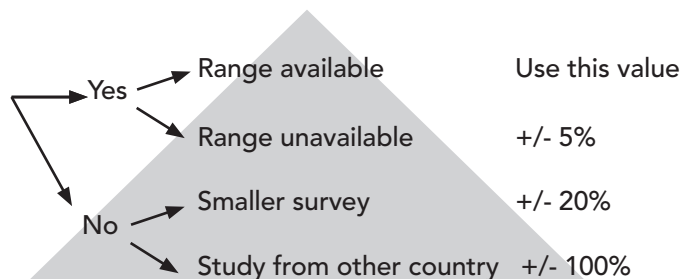
Source: Rapiti E, Hutin Y, Dhingra N. The global burden of HBV, HCV and HIV infections attributable to unsafe blood transfusions. WHO Unpublished report

## APPENDIX B

### Uncertainty analysis: General guidelines on how to assign ranges on the user-specified input values

The levels of uncertainty around the input parameters can be related to the quality of studies that estimates are derived from, variation in estimates between studies, sample size and power, representativeness and generalisability of study estimates, all of which are indicative of the overall quality of the input data. Clearly there is a hierarchy of inputs. Many inputs are based on national surveys and should have ranges as specified by those surveys, these are generally provided in the surveys' appendices. However, not all the variables we use in this model will have specified ranges. The ranges on national prevalence are usually fairly small but a range of  $\pm 5\%$  for survey derived values would be appropriate. Other values which are based on smaller, non-national survey (sex worker surveys, for example) will have larger ranges, on the order of 20%. Values taken from studies in other countries (percent of MSM, for example) should have even larger ranges, on the order of 100%. It is probably better to estimate ranges that are too large rather than too small, since the restriction of the final output to a range of total number of new infections provides a control for unrealistic combinations. A diagram summarizing these guidelines is presented below.

Flowchart indicating uncertainty ranges for model inputs depending on their source.



Other possible guidelines...

1. General criteria for rating data/study quality

Criteria	Very Good	Good	Medium	Poor
Sample size				
Study Power				
Representativeness				
Generalisability				
Recentness				

2. Classification of estimates of high risk groups' sizes  
(scoring used by Aceijas et al., 2006)<sup>11</sup>

Estimates produced using indirect single or multiple methods (for example, capture-recapture, multiplier)	A
Estimates from population based surveys	B
Experts' judgment and information on how the estimate was produced (for example, Rapid Assessment and Response (RAR) studies) and registered cases	C
Estimates reported without technical information	D

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## NOTES



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