Economic & Social Affairs

# United Nations Expert Meeting on Software for Demographic Projections of HIV/AIDS

New York, 10-11 May 2005

## Report of the Meeting

United Nations

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**Department of Economic and Social Affairs**
Population Division

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# DESA

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## Note

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# UNITED NATIONS EXPERT MEETING ON SOFTWARE FOR DEMOGRAPHIC PROJECTIONS OF HIV/AIDS

## A. BACKGROUND

At the meeting of the UNAIDS Reference Group held in Sintra, Portugal in 2004, it was suggested that a review of the various software implementations of the Reference Group's model of the dynamics of the HIV/AIDS pandemic would be useful. Responding to that suggestion and in preparation for the meeting of the UNAIDS Reference Group that would be held in Tours, France in July 2005, the Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat convened in New York, from 10 to 11 May 2005, an Expert Meeting on Software for Demographic Projections of HIV/AIDS.

The objective of the meeting was to evaluate, compare and improve procedures for the estimation and projection of the demographic impact of the HIV/AIDS pandemic. The meeting brought together relevant actors working on the development of software to estimate the demographic impact of HIV/AIDS, namely, representatives of the U.S. Census Bureau, the Futures Group and the Population Division (the full list of participants is presented in an annex to this report). Participants discussed the differences in terms of both methodology and functionality in the three main software packages used to estimate and project the demographic impact of HIV/AIDS. Their main objective was to identify areas for further improvement so as to achieve greater consistency in the population estimates and projections produced by the different packages under similar assumptions.

## B. THE DIFFERENT SOFTWARE APPLICATIONS

Mr. Thomas Buettner, Chief of the Estimates and Projection Section (Population Division), opened the meeting and welcomed participants. He stressed the importance of careful scrutiny of the performance of software packages to ensure that the estimates and projections of the impact of HIV/AIDS met the highest standards especially because of their importance for policy and public debate. He noted that cooperation between the participating institutions was well established and invited participants to two days of open discussion and fruitful information exchange.

The meeting continued with a series of presentations on the major features and approaches implemented in the different software packages. First, Mr. Peter Johnson, representing the U.S. Census Bureau, made a comprehensive presentation of the software used by the U.S. Census Bureau, named RUPHivAids, to incorporate the impact of HIV/AIDS in the demographic dynamics of affected populations. In that software, the HIV/AIDS epidemic is driven by incidence levels that are derived by iteration so that they match observed prevalence levels of HIV/AIDS, as supplied by UNAIDS. The software includes procedures that distribute events into single calendar years, taking account of competing risks between background mortality and mortality due to AIDS. RUPHivAids produces a comprehensive set of epidemiological and demographic outputs.

Mr. John Stover, representing the Futures Group, discussed the mode of operation of SPECTRUM, the software package developed by the Futures Group. In contrast with the approach followed by RUPHivAids, SPECTRUM models the impact of the epidemic starting with the overall prevalence of HIV/AIDS among adults and by assuming a distribution by age and sex for that prevalence. Parameters defining incidence are then back-calculated from the imputed prevalence by age and sex. Mr. Stover noted that one of the primary advantages of SPECTRUM was its user-friendly interface and that users generally employed the program to build scenarios for advocacy purposes or as guidance for policy formulation.

Mr. Buettner presented the software named AbacusDIM which is used by the Population Division for the estimation and projection of the demographic impact of HIV/AIDS. He noted that, similarly to RUPHivAids, AbacusDIM was driven by incidence levels. This demographic implementation of the UNAIDS reference group model was developed so as to be consistent with that in the Estimation and Projection Package (EPP) used by UNAIDS. In an actual application, AbacusDIM was used to fit the estimated trends in HIV prevalence supplied by UNAIDS. In most cases, past trends in HIV prevalence were fitted using constant parameters. However, projections were made by changing the value of the fitted parameters in a systematic way in all countries.

Mr. Buettner explained that to estimate the number of deaths due to AIDS by age and sex, AbacusDIM projected the infected population over time using a multi-state approach that took into account the competing mortality risks between "background mortality" (that is, mortality without HIV/AIDS) and mortality due to HIV/AIDS. AbacusDIM assumed that the median survival time since infection was one year longer than that recommended by UNAIDS. This change was based on the observation that the original survival function estimated by UNAIDS had been calculated from empirical observations that incorporated the effect of background mortality, that is, the deaths of HIV-positive persons included in the data were not necessarily caused exclusively by AIDS. By adding a year to the median survivorship of persons infected by HIV, the AbacusDIM application counterbalanced the effect of background mortality.

In this regard, Mr. Buettner recalled that the UNAIDS Reference Group had recommended a median survival time of 8.6 years for males and 9.4 years for females after infection by HIV (The UNAIDS Reference Group on Estimates, Modelling and Projections, 2002). These survival periods were obtained from cohort studies that included deaths not due to AIDS among HIV-positive individuals and reflected, therefore, also background mortality (Porter and Zaba, 2004). According to Porter and Zaba, results from the Kisesa cohort suggest that deaths not due to AIDS account for approximately 10 per cent of all deaths among HIV-positive persons. This is the basis for the adjustment in survivorship time introduced in AbacusDIM.

Mr. Buettner observed that in a population highly affected by the HIV/AIDS epidemic, HIV-negative persons might yet be subject to higher risks of death that they would have been in the absence of the HIV/AIDS epidemic because of the effects the epidemic might have in overtaxing health services or in increasing the prevalence of other infectious diseases, such as tuberculosis. That is, "background mortality" in the AbacusDIM should not be interpreted as the level of mortality that would have prevailed in the absence of the epidemic.

Ms. Tammany Mulder of the U.S. Census Bureau presented the results of the comparison of the three software applications being discussed. To do so, each program was run using as input a stationary population and selecting parameters of change that would maintain stationarity during the projection period in the absence of AIDS. To the extent possible, any additional parameters used as input were the same in all applications. However, some differences in parameter inputs could not be avoided because of the different input specifications of each software application.

Ms. Mulder presented the resulting levels and trends for a series of output indicators produced by the different software applications according to two scenarios: the first assumed that there was no HIV/AIDS in the population (No-AIDS scenario) and the second assumed a non-zero prevalence of HIV/AIDS (AIDS scenario). Significant differences were identified between the outputs of the respective applications under particular circumstances. For instance, under the No-AIDS scenario, the population projected using SPECTRUM did not remain stationary as it should have. Similarly, in the AIDS scenario, AbacusDIM produced a relatively high number of infected births. The causes of these and other discrepancies were discussed by the meeting participants, which included all the key programmers behind the different software applications. The meeting thus proved very successful in making possible the identification of possible errors in existing software or in determining which features required improvement. The discus-

sion resulted in a number of suggestions and recommendations for the further revision of existing software.

Ms. Mulder and Mr. Johnson have since prepared a paper presenting a systematic comparison of the performance of the three software applications from a variety of perspectives. This paper was presented at the XXV International Population Conference held in Tours, France, in July 2005 and at the meeting of the UNAIDS Reference Group that followed the Conference and was also held in Tours. Those responsible for each of the software applications reviewed the evidence and said they would make the necessary changes over the course of the year.

## C. IDENTIFICATION OF KEY AREAS FOR WHICH MORE EMPIRICAL INFORMATION IS NEEDED

### *Adult mortality*

Participants noted the scarcity of empirical information on background mortality and emphasized its importance for the estimation of the demographic impact of HIV/AIDS. As Mr. Buettner had suggested, background mortality seemed to be affected by the epidemic and there were some signs that its level was not declining but was rather stagnating. Such stagnation was likely due to the strains that the epidemic was putting on the public health systems of poor countries as well as to the competing demand for attention, care and resources associated with a growing number of HIV-positive patients.

Because in most of the countries affected by the HIV/AIDS epidemic reliable information on adult mortality was very scarce, both the Population Division and the U.S. Census Bureau relied on child mortality estimates derived from data gathered in demographic surveys to infer levels of adult mortality via model life tables. Yet, not only was it unclear to what extent estimated mortality in childhood already included the effect of mortality caused by AIDS but, in addition, the relation between the level of mortality in childhood and adult mortality net of AIDS deaths might not be well represented by existing models. Undoubtedly, there was a need for more and better data on deaths above age 5 to estimate adult mortality. Because most the highly-affected countries lacked a working system of civil registration that could produce the required data, participants suggested alternative approaches to obtain the necessary data, including via special questions included in population censuses, via specialized surveys that might include data on cause of deaths validated by verbal autopsies, and data on particular areas generated by continuous surveillance systems such as those in the sites belonging to the INDEPTH network.

### *HIV incidence and prevalence by age and sex*

A comparison of the age-specific incidence of HIV infection generated by RUPHivAids and AbacusDIM showed that levels and trends were quite different, especially in the case of males. Overall, the age pattern of new infections used in AbacusDIM appeared to be too young when compared to other models. In comparison, the age pattern of new infections used in RUPHivAids appeared to be fairly high at advanced ages for males. Consequently, RUPHivAids produced more deaths in advanced ages, while AbacusDIM produced substantially more deaths among young adults.

It was suggested that the younger age pattern of new infections in AbacusDIM, which yielded a higher number of young infected women, could partially explain the higher number of infected births that the program yielded in comparison with that produced by RUPHivAids. Therefore, an assessment of the age distribution of new infections used by AbacusDIM was necessary, particularly with respect to the younger age groups (15-19 and 20-24) which had a higher influence in the resulting number of births especially in high-fertility countries.

It was suggested that further analysis of age at first intercourse by country, based on DHS data or that from other similar surveys, could yield insights on the likely age pattern of infection. The sharp rise in HIV incidence at young ages could then be adjusted accordingly.

The importance of using all available data on levels of HIV prevalence by age and sex, such as newly available data from DHS surveys and other sources, was emphasized. It was noted, however, that the data available were subject to considerable random variability and it was therefore important to control for such variability by taking into account sample size and design before such data could be used to validate the models used.

Another problem flagged during the discussion was the use of different denominators to estimate HIV prevalence. For instance, the estimates used by the Population Division referred to the population aged 15 years or over, a measure of prevalence consistent with the internal workings of the epidemiological model implemented in EPP and used by UNAIDS. However, the estimates published by UNAIDS are interpreted as reflecting prevalence among the population aged 15 to 49. This inconsistency of interpretations implies that compared to the published UNAIDS prevalence estimates, those used in AbacusDIM actually overestimate the prevalence among the 15-49 population.

*Differential fertility by seropositive status*

All three software applications incorporate models that allow for the existence of lower fertility levels among HIV-positive women. Each program adjusts the fertility levels of infected and non-infected women so that the overall fertility level matches that input by the user. It was suggested that the procedure used by AbacusDIM should be modified so that the adjustments ensure that overall fertility is matched age group by age group.

*The impact of international migration*

When a population was subject to significant migrant inflows, it was not clear how one should deal with the likely change in prevalence associated with this inflow. Should it be assumed that the migrants were equally likely to be HIV-positive as the population at destination? Should the migrants be considered as the carriers of the epidemic? None of the three software applications made any allowance for migrants being the vectors of contagion. In RUPHivAids and SPECTRUM, in-migrants were assumed to be HIV-negative upon arrival and were then subject to the same risks of infection as the population at destination. AbacusDIM did not make allowance for migration within the epidemiological module and therefore assumed implicitly that migrants were subject to the same prevalence as the population of destination from their moment of arrival. Given that in-migration was generally low in the most affected countries, a more sophisticated modelling of the effect of HIV on the migrant population would probably have only a limited effect on the estimation of the impact of AIDS or on the dynamics of the epidemic. However, in countries where migration was moderate and HIV prevalence was high, modelling properly the impact of migration could significantly change the dynamics of the epidemic. Some attempt at assessing the likely effects of moderate in-migration might be useful.

*Modelling the effects of anti-retroviral treatment*

There were extensive discussions on the effects that treatment would have on the epidemic. All three software applications already had special modules modelling the impact of treatment. Participants agreed that modelling treatment should become a priority in future software development. Mr. Johnson noted that data on anti-retroviral treatment (ART) were based on different definitions and circumstances. In some instances, countries reported ART coverage as a goal rather than as a reality. Furthermore, there was the complex issue of deciding at what stage of the disease patients ought to be treated. More information on

this point was necessary in order to decide how much time should elapse between infection and the onset of treatment in the models being implemented. Currently, the rule of thumb being used in modelling is that patients would get treatment only when they reached the stage of full-blown AIDS or one year before that stage was reached. It was also necessary to deal differently with treatment in children and in adults.

Until 2002, the projections prepared by the Population Division had no explicit parameter related to treatment. Although the current version of AbacusDIM made explicit allowance for the introduction of treatment, projections about future incidence were also driven by changes in other parameters, under the assumption that behavioural change would take place and contribute significantly to reduce the spread of the epidemic.

*Countries with very high prevalence*

For a number of countries, especially those with very high HIV prevalence, the fitted prevalence curves used as input for AbacusDIM are slightly lower than those produced by UNAIDS, though prevalence levels for 2003 are within the range published by UNAIDS. For those countries, a reduction in prevalence levels was necessary to match the population enumerated in recent censuses and to obtain mortality levels closer to existing independent estimates. In addition, in countries with relatively high HIV prevalence, the sex ratios of new infections were gradually moved toward 1.0 in order to avoid a severe reduction of the female population and implausible differentials in projected mortality levels in favour of men. Mr. Johnson reported that similar adjustments were being made in preparing the U.S. Census Bureau projections for countries with very high HIV prevalence.

The Population Division said that it would make available country-specific life tables for use as models of background mortality over the period 1980 to 2050. The Population Division would also provide a set of regional migration patterns to all participants.

## D. RECOMMENDATIONS

Participants agreed to the following set of recommendations and commitments:

1. To share with UNAIDS and the Reference Group information and experience gained during the preparation of demographic estimates and projections. Of particular interest are the implications of the use of imbalanced sex ratios of prevalence over the long term with respect to the resulting overall prevalence levels, median survival time, sex imbalances etc.

2. To continue discussion on whether inconsistencies between levels of HIV prevalence estimated by UNAIDS and the results of recent censuses can be used to adjust the estimated prevalence or other key parameters used in modelling the epidemiology of the disease.

3. To take account of the effect of background mortality in empirical data to adjust the median survival of HIV-positive persons for purposes of modelling.

4. To request that the UNAIDS Reference Group make recommendations on the age and sex pattern of new infections taking account of newly available data.

5. To request that the UNAIDS Reference Group re-examine the median survival time after the onset of full blown AIDS both in generalized and in concentrated epidemics, and in developing or developed country settings.

6. To request that the UNAIDS Reference Group epidemiological model of the HIV/AIDS epidemic as implemented in EPP make provisions for the introduction of anti-retroviral treatment and other likely interventions.

7. To request UNAIDS that aggregation of sub-national epidemics in EPP be carried out taking account of the differential population dynamics in urban and rural areas.

8. To explore the possibility of producing epidemiological parameters appropriate for use in modelling the epidemic in groups of countries, including, as appropriate, regional groups, development groups or countries groups by type of epidemic.

9. To continue the exchange of information among the organizations participating in the meeting especially with respect to production cycles and important deadlines so as to coordinate activities better.

## REFERENCES


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**9 May 2005**

**English only**

UNITED NATIONS EXPERT MEETING ON SOFTWARE
FOR DEMOGRAPHIC PROJECTIONS OF HIV/AIDS
United Nations Secretariat
Department of Economic and Social Affairs
Population Division
New York, 10-11 May 2005

## ORGANIZATION OF WORK

The objective of the meeting is to improve and expand procedures for the estimation and projection of the demographic impact of the HIV/AIDS pandemic. Specifically, the group will discuss the demographic and epidemiological methods and assumptions underlying the three main software packages used in the estimation and projection of the demographic impact of HIV/AIDS. It will compare existing approaches and identify key areas for further improvement in the production of consistent and comprehensive demographic estimates and projections that make allowance for the impact of the HIV/AIDS epidemic.

**Tuesday, May 10th 2005**

*Morning session:* *9:30-12:30*

1. **OPENING OF THE MEETING:** Mr. Thomas Buettner

2. **PRESENTATIONS OF THE DIFFERENT SOFTWARE APPLICATIONS**

   a) Peter Johnson, United States Census Bureau
   b) John Stover, Futures Group
   c) Thomas Buettner, United Nations Population Division

*Lunch break:* *12:30-14:30*

*Afternoon Session:* *14:30-17:30*

**3. DISCUSSION OF THE DIFFERENT SOFTWARE APPLICATIONS.**
NOTE: This session will start by a brief presentation of IPC on preliminary results of comparisons of software packages, followed by a systematic comparison of approaches used to estimate the demographic impact of HIV/AIDS.

**A. DISCUSSION OF APPROACHES TO DERIVE AND MODEL DEMOGRAPHIC ESTIMATES AND PROJECTIONS FOR UNINFECTED POPULATIONS**

Topics included:

- Approaches for estimating and forecasting No-AIDS mortality: use of model life tables; splicing of life tables (child mortality vs. adult mortality); infant and child mortality and separation factors
- Fertility and migration for the No-AIDS scenarios

**B. DISCUSSION OF MODELING AND PROJECTING HIV/AIDS INFECTED POPULATIONS, AND ESPCIALLY HIV/AIDS RELATED MORTALITY**

Topics included:

- HIV incidence levels versus HIV prevalence levels *(conversion of prevalence 15-49 to 15+)*
- Sex ratio of infection and age pattern of infection by sex (variation by region, over time and by type of epidemic, that is concentrated vs. general epidemics)
- Median incubation period and median survival time once HIV has developed to full blown AIDS (variation by sex and by availability of treatment)
- Mother to child transmission (variation by region and by availability of treatment)
- Fertility and migration in the context of the HIV/AIDS epidemic

**Wednesday, May 11th 2005**

*Morning session: 9:30-12:30*

4. **HANDS-ON COMPARISION AND DISCUSSION OF THE DIFFERENT SOFTWARE PACKAGES**
   NOTE: This session provides an opportunity to a hands-on comparison of the software packages used and the differential impact of the HIV/AIDS epidemic on key demographic indicators such as IMR, Q5, 45q15 and life expectancy at birth, the proportion of deaths by age attributed to HIV/AIDS, and others.

*Lunch break:* *12:30-14:30*

*Afternoon Session:* *14:30-17:30*

5. **DISCUSSION ON THE IMPLEMENTATION OF TREATMENT, OTHER TOPICS**
   - Measures of ARV (coverage of treatment, efficiency) and their implementation into the estimation and projection procedures
   - Impact of treatment options on survival (constant vs. age dependant survival)
   - Possibility of establishing regional sets of epidemiological and treatment parameters

6. **DISCUSSION AND CONCLUSIONS/RECOMMENDATIONS**
   - Summary of findings, identification of priority topics for further improvement
   - Suggestions for the UNAIDS Reference Group Meeting in Tours, June, 2005

7. **CLOSING OF THE MEETING**

UN/POP/POPAIDS/2005/INF.2

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New York, 10-11 May 2005

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