Development and future directions for the Joint United Nations Programme on HIV/AIDS estimates

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Introduction

Every year, the Joint United Nations Programme on HIV/AIDS (UNAIDS) produces estimates that chart the magnitude of the worldwide HIV epidemic, its impact and the progress taken to curb its spread and reduce its impact. The UNAIDS Reference Group on Estimates, Modelling and Projections [1] exists to review and develop the methods supported by UNAIDS to generate national estimates of HIV and related indicators. UNAIDS and its Reference Group routinely produce special editions of scientific journals to document the methods used to produce the UNAIDS estimates and to provide updates on the directions the methods are expected to take in the future [2–6].

The work of the Reference Group is two-fold – to continually calibrate, update and validate the methods, while simultaneously extending the methods to take advantage of new data sources, and to adapt approaches so as to maximise their usefulness to country programme planning and in evaluation. The articles in this supplement fall into both of these categories. Two articles document recent improvements to the estimation and projection models that are used, and another compares the UNAIDS estimates with other sets of published estimates and data. Several other articles show how the methods have expanded to accommodate the need to better understand data requirements for young children and older people; how estimates of key indicators are produced at finer spatial scales; and finally, how methods can and will synthesise newly available data into estimates. We address each of these topics in turn below.

Together, these updates, modifications and new methods aim to provide more accurate knowledge and better understanding of HIV epidemics which should inform and assist programme planners and decision makers, as well as scientists, researchers and the wider public.

Developments in the estimation tools

The Estimation and Projection Package (EPP) and the AIDS Impact Module (AIM) in Spectrum were used by 158 countries to produce the 2013 estimates of HIV and HIV-related indicators [7]. EPP and Spectrum are the core set of tools used by UNAIDS and are continually under development. Brown *et al.* [8] describe the three models that can be fit to prevalence data in EPP– r-spline, r-trend and EPP classic. This new repertoire of models should enable many types of epidemic trajectory to be captured and uncertainty in the shape of the epidemic curve represented where data are sparse. Stover *et al.* [9] describe, among other changes, how the AIM module now includes a procedure whereby, in large epidemics, the total death rate is made consistent with published projections through modification of background mortality rates where necessary. Another important update is in the methods used for estimating the number of orphans, which now include the changing effects of antiretroviral therapy (ART) and prevention of mother-to-child transmission (PMTCT) programmes over time as guidelines have changed [9]. Lastly, Stover *et al.* [9] describe how ART need based on the new WHO guidelines (reflecting recommendations for ART initiation regardless of CD4+ cell count for serodiscordant couples, HIV-positive pregnant women and all HIV-positive children under 5 years, among others) can be reflected in the model.

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In this category, the Reference Group had also been concerned that models were not fully incorporating information on the excess death rates experienced by people who inject drugs (PWID). In response to these concerns, Mathers and Degenhardt [10] updated a previous systematic review [11] to examine non-AIDS mortality in PWID. They examine differential effects of non-AIDS mortality in PWID by region, income status, sex, HIV status and whether opioid substitution therapy is used. Non-AIDS mortality in HIV-positive PWID (at 2.51 per 100 person-years) was found to be 1.5 times higher than among HIV-negative PWID (at 1.66 per 100 person-years). Although additional differences appear to exist, more representative data are required, particularly in low-income and middle-income countries, to improve model estimates.

A new focus on young children and older adults

Originally, estimates were published only for adults 15–49 years. This focus has expanded over time in parallel with the epidemic ageing into older age groups and with cohorts of children infected. Maternal and child health is a major global priority, and HIV plays a significant role, particularly in sub-Saharan Africa. Understanding trends in paediatric infections and the need for ART in this group is critical, not only for health systems and programme management, but also for planning future drug procurement and development. Penazzato *et al.* [12] explore different plausible scenarios to estimate the potential future need for paediatric ART. They find that, even under the most optimistic prevention scenarios, by 2020 there will be nearly 2 million children living with HIV, signifying the importance for age-appropriate drug regimens.

It is becoming increasingly important to better understand the size of the older population living with HIV. In sub-Saharan Africa, where the burden of infection is greatest, surveillance in older populations has been limited. Mahy *et al.* [13] present estimated trends in prevalence over time showing that HIV prevalence among those aged over 50 years has increased considerably over time. However, there still appear to be some discrepancies between national surveys and estimates, which underline the need for expanded surveillance in older populations to improve the programmatic response and to better understand the health needs of this population.

Estimates that are responsive to programme managers needs

Countries require programme-relevant information at sub-national levels to support local planning, decision making and resource allocation. With the tools available at present, it is possible to produce estimates at finer geographic levels. For example, Mahy *et al.* [14] describe the process of producing state-level estimates in Nigeria using EPP and Spectrum and the challenges that result from using the more limited data available at this level and issues in model selection for each state. In the future, hierarchical and spatial models may allow researchers to better address these limitations.

The spatial distribution of people living with HIV in sub-Saharan Africa, at a much finer resolution, is described by Larmarange and Bendaud [15] using an approach that combines geolocation information from national population-based surveys with estimates of prevalence from EPP/Spectrum. This approach represents an initial phase of method development to represent spatial variation in order to better understand heterogeneity across national epidemics and has already had an impact in how programme managers are able to understand the epidemics they face.

New methods have also been added that allow the incidence of tuberculosis disease among HIV-positive persons to be estimated. Tuberculosis and HIV coinfection is a Millennium Development Goal target indicator for countries in sub-Saharan Africa but, until now, estimates have only been made at the regional level and have not necessarily been integrated with the data available on HIV epidemics. Here, Pretorius *et al.* [16] detail the methods used to estimate tuberculosis–HIV incidence and mortality at the country level allowing for coherence between existing tuberculosis incidence and mortality estimates [17], while leveraging other HIV estimates, such as HIV prevalence and the CD4+ cell count distribution of the HIV-infected population. This part of the model will expand in the future to incorporate additional tuberculosis data to improve these estimates.

Leveraging more data sources to strengthen estimates

A key aim for ongoing method development is to incorporate all available data sources to strengthen estimates. To date, estimates coordinated by UNAIDS have largely relied on surveillance data (particularly data from women attending antenatal care (ANC) and from targeted surveys among key populations) and national survey data (e.g. household-based Demographic and Health Surveys) to inform both the overall trends and the level of HIV prevalence. In concentrated epidemics, many countries do not have all the data required (including nationally representative data for key populations and size estimates), but do have additional data sources such as detailed case report and vital registration data which may be used to better inform estimates.

Stover *et al.* [9] describe a new approach used in Argentina, Mexico and Brazil for their 2013 estimates whereby incidence trends, based on fits to prevalence data, are selected to better match programme estimates of

new HIV diagnoses, people living with HIV and/or deaths due to HIV/AIDS. Another method which does not rely on prevalence data and size estimates of key populations but instead utilises only case report data to estimate incidence is described by Vesga *et al.* [18] and applied in Colombia. For the same reason of aiming to leverage additional data to check projections, the new version of EPP includes a procedure for comparing estimates, with ad hoc data on AIDS case reports and small local surveys, which have been assembled into a database [8]. These approaches are intended to bring historical estimates of new HIV infections and AIDS deaths in better alignment with other national data. It is expected that use of these approaches will increase in the future as the methods are further developed and refined, and additional data sources are integrated.

Brown *et al.* [8] and Marsh *et al.* [19] describe how national population-based surveys are now directly included in the fitting process in EPP, which allows survey trends to inform the fitting and allows for more appropriate representation of uncertainty. Marsh *et al.* [19] additionally analyse prevalence in national surveys compared with ANC prevalence to derive updated calibrations for ANC data in countries without a national population-based survey. In order to further examine how these two data sources (ANC data and household surveys) should be considered together, Eaton *et al.* [20] compare prevalence trends among pregnant women with prevalence trends among all women in the general population. The authors illustrate that, in sub-Saharan Africa, over time the age distribution of HIV prevalence has shifted towards older women, who are less likely to become pregnant and be captured in ANC surveillance, so that observed ANC prevalence trends could have exaggerated the extent to which HIV prevalence in the general population has declined. This would have important implications for use of ANC data to inform population-level trends. Age-structured modelling frameworks that explicitly account for fertility schedules may be less susceptible to these issues and are a significant avenue for further investigation.

Incidence assays are an additional potential source of data which may strengthen estimates by providing cross-sectional measures of incidence. While some countries have already used incidence assays, more countries are planning for their inclusion in future national population-based surveys. Bao *et al.* [21] present methods that incorporate incidence assays, or combinations of assays, into the fitting process in EPP. The authors illustrate how the effect of including assays is largely dependent on the sample size and the calibrating parameters of the assay (the false recent rate and the mean duration of recent infection). Data from assays used in a single survey with small sample sizes will have only a modest effect on informing estimates and results may be biased if the calibrating parameters are not accurate. However, the added value of these assays is expected to increase in the future with multiple measures of incidence and improved calibrating parameters.

The use of different data sources and methods for estimation can lead to different results. Hallett *et al.* [22] compare estimates of HIV incidence, prevalence and mortality from the Global Burden of Disease (GBD) Study 2013 [23] with UNAIDS estimates, and triangulates these estimates with other data where available. The authors illustrate how HIV incidence estimates from the GBD Study 2013 are substantially lower than HIV case report data in countries with strong surveillance systems including the United States, the United Kingdom, Australia and France among others. The mortality trends in the Murray *et al.* [23] study suggest a much shallower reduction in the era of ART than UNAIDS has estimated. Population-based cohorts, however, offer the opportunity to examine real trends in mortality, albeit in selected small locations. Reniers *et al.* [24] in this supplement present trends in mortality among people living with HIV from population-based cohort studies in East and Southern Africa which illustrate declines in mortality rates of more than 50% in the ART era compared with the pre-ART era.

The work of bringing more data sources to bear on the estimates is ongoing and is intended to strengthen future sets of estimates produced by UNAIDS. Additional data sources that will become integrated in the coming rounds of methods revisions may also include data from HIV testing of pregnant women in PMTCT programmes. The Reference Group also calls for further data collection especially related to ART: confirmed numbers of new initiators, numbers currently in care, age distributions and CD4+ cell counts at ART initiation, among other factors.

In conclusion, UNAIDS supports and empowers countries to develop their own estimates, simultaneously harnessing local knowledge and understanding of epidemics and fostering the routine application of the estimates in programme planning. The studies in this collection emphasise the dynamic nature of the methods that are used to produce the UNAIDS estimates. Further changes can be expected in the coming years as new data sources become available, additional opportunities to validate the estimates present themselves, and the needs of programme managers continue to evolve.

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Conflicts of interest

There are no conflicts of interest

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