Methods for deriving UNAIDS estimates

Introduction

UNAIDS annually provides revised global, regional and country-specific modelled estimates to track the HIV epidemic, using the best available epidemiological and programmatic data. Modelled estimates are required because it is impossible to count the exact number of people living with HIV, people who are newly infected with HIV or people who have died from AIDS-related causes in any country. Knowing this for certain requires testing every person for HIV regularly and investigating all deaths, which is logistically impossible and ethically problematic. Modelled estimates and the lower and upper bounds around these estimates provide a scientifically appropriate way to describe HIV epidemic levels and trends.

Partnerships in developing methods for UNAIDS estimates

Country teams use UNAIDS-supported software to develop estimates annually. The country teams comprise primarily epidemiologists, demographers, monitoring and evaluation specialists and technical partners.

The software used to produce the estimates is Spectrum—developed by Avenir Health (www.avenirhealth.org)—and the Estimates and Projections Package, which is developed by the East-West Center (www.eastwestcenter.org). The UNAIDS Reference Group on Estimates, Modelling and Projections provides technical guidance on the development of the HIV component of the software (www.epidem.org).

Brief description of methods used by UNAIDS to create estimates

For countries where HIV transmission is high enough to sustain an epidemic in the general population, available epidemiological data typically consist of HIV prevalence results from surveillance among pregnant women attending antenatal care clinics and from nationally representative population-based surveys. Because antenatal clinic surveillance is performed regularly, these data can be used to inform national prevalence trends, whereas data from population-based surveys—which are conducted less frequently but have broader geographical coverage and also include men—are more useful for informing national HIV prevalence levels. For a few countries in sub-Saharan Africa that have not conducted population-based surveys, HIV prevalence levels are adjusted based on comparisons of antenatal clinic surveillance and population-based survey data from other countries in the region. The HIV prevalence curves and numbers of people on antiretroviral therapy are then used to derive an estimate of HIV incidence trends.

Historically, countries with high HIV transmission have produced separate HIV prevalence and incidence trends for rural and urban areas when there are well established geographical differences in prevalence. To better describe and account for further geographical heterogeneity, an increasing number of countries have produced subnational estimates (such as at the province or state level) that, in some cases, also account for rural and urban differences. These subnational or rural-urban estimates and trends are then aggregated to obtain national estimates using Spectrum.

In countries with low-level HIV epidemics where HIV transmission occurs largely among key populations at higher risk of HIV infection (such as people who inject drugs, sex workers or gay men and other men who have sex with men), the data from repeated HIV prevalence studies—usually focused on key populations—are most often used to inform national estimates and trends. Estimates of the size of key populations are increasingly derived empirically in each country or, when studies are not available, based on regional values and consensus among experts. Other data sources—including population-based surveys, surveillance among pregnant women and HIV case reporting data—are used to estimate the HIV prevalence in the general, low-risk population. The HIV prevalence curves and numbers of people on antiretroviral therapy are then used to derive national HIV incidence trends.

For many countries in western and central Europe and North America and in Latin America and the Caribbean that have insufficient HIV surveillance or survey data—but have strong vital registration and disease reporting systems—HIV case reporting and AIDS-related mortality data are used to directly inform trends and levels in national HIV prevalence and incidence. These methods also allow countries to take into account evidence of underreporting or reporting delays in HIV case report data, as well as the misclassification of deaths from AIDS-related causes.

In all countries where UNAIDS supports the development of estimates, assumptions about the effectiveness of HIV programme scale-up and patterns of HIV transmission and disease progression are used to obtain age- and sex-specific estimates of the number of people living with HIV, the number of people newly infected with HIV and the number of people dying from AIDs-related causes as well as other important indicators (including programme coverage statistics). These assumptions are based on systematic literature reviews and analyses of raw study data by scientific experts. Demographic population data, including fertility estimates, are derived from the latest revision of the United Nations Population Division's World Population Prospects.

Selected inputs into the model—including the number of people on antiretroviral therapy and the number of women accessing services for preventing the mother-to-child transmission of HIV by type of regimen—are reviewed and validated in partnership with the World Health Organization (WHO), the United Nations Children's Fund (UNICEF) and other partners.

Final country-submitted files containing the modelled outputs are reviewed at UNAIDS to ensure that the results are comparable across regions and countries and over time.

Uncertainty bounds around UNAIDS estimates

The software calculates uncertainty bounds around each estimate that define the range within which the true value (if it could be measured) lies. Narrow bounds indicate that an estimate is precise, and wide bounds indicate greater uncertainty regarding the estimate.

In countries using HIV surveillance data, the quantity and source of the data available partly determine the precision of the estimates; countries with more HIV surveillance data have smaller ranges than countries with less surveillance data or smaller sample sizes. Countries in which a national population-based survey has been conducted generally have smaller ranges around estimates than countries where such surveys have not been conducted. In

countries using HIV case reporting and AIDS-related mortality data, the number of years of data and the magnitude of the cases reported or AIDS-related deaths observed will contribute to determining the precision of the estimate.

The number of assumptions required to arrive at the estimate also contributes to the extent of the ranges around the estimates: in brief, the more assumptions, the wider the uncertainty range, since each assumption introduces additional uncertainties. For example, the ranges around the estimates of adult HIV prevalence are smaller than those around the estimates of HIV incidence among children (which require additional data on the probability of mother-to-child HIV transmission). The latter are based on prevalence among pregnant women and the probability of mother-to-child HIV transmission.

UNAIDS is confident that the actual numbers of people living with HIV, people who are newly infected with HIV or people who have died from AIDS-related causes lie within the reported ranges. Over time, more and better data from countries will steadily reduce uncertainty.

Improvements to the 2016 UNAIDS estimates model

Country teams create new Spectrum files every year. The files may differ from one year to the next for two reasons. First, new surveillance and programme data are entered into the model; this can change HIV prevalence and incidence trends over time, including for past years. Second, improvements are incorporated into the model based on the latest available science and understanding of the epidemic. Because of these improvements to the model and the addition of new data to create the estimates for each year, the results from previous years cannot be compared with the results from this year. A full historical set of estimates has also been created for this year, enabling a description of trends over time.

Between the previous and 2016 rounds of estimates, the following changes were applied to the model under the guidance of the UNAIDS Reference Group on Estimates, Modelling and Projections and based on the latest scientific evidence.

- Updated demographic data from the United Nations Population Division's *World Population Prospects, 2015 Revision* were used as the basis for the demographic projections in the model.

- For countries with high-burden epidemics that model separate HIV prevalence and incidence trends for rural and urban areas, the distribution of the urban population was updated using the *World Urbanization Prospects 2014* data set.

- In the adult estimation model, the probability of dying for those on antiretroviral therapy was updated based on data provided to UNAIDS by the IeDEA Consortium.

- The probabilities of HIV transmission during pregnancy, delivery and breastfeeding have been updated based on a comprehensive and recent review of published literature. Most importantly, the estimated transmission probability among women who seroconvert during pregnancy or breastfeeding was significantly lower than a previous review of the literature had found. As a result, the number of children estimated to have become infected was revised downward in the current model.

- The estimation model for children was modified to apply a probability of initiating antiretroviral therapy by the child's age, year and geographical region rather than assuming that antiretroviral therapy was initiated when the child became eligible for treatment. The new probabilities were based on special analyses done for UNAIDS by the IeDEA Consortium and provided region-specific probabilities. As a result of more accurately reflecting when children initiate antiretroviral therapy, the number of children estimated to have survived in previous years has been corrected downwards.

- Wider use was made of the AIDS Epidemic Model developed by the East-West Center and the case reporting and mortality fitting tools in Spectrum to construct national prevalence and incidence trends in countries with concentrated epidemics. This improved the overall accuracy of the estimates in these countries.

- For countries using HIV case reporting and mortality data as model inputs, uncertainty around the incidence curve has been integrated into the incidence fitting process. As a result, the uncertainty bounds for countries using this approach were narrower than in the previous year.

More detailed information on these revisions to the 2016 model can be found at www.epidem.org and in a collection of topical articles by the UNAIDS Reference Group on Estimates, Modelling and Projections to be published in a journal supplement to be released in December 2016.

Measuring antiretroviral therapy coverage

Since 2013, UNAIDS has provided the number and estimates of the proportion of adults and children living with HIV who are on antiretroviral therapy (rather than estimates of the proportion of adults and children eligible according to national or international guidelines who are on antiretroviral therapy). This coverage reflects the WHO recommendations of starting antiretroviral therapy among everyone diagnosed as HIV-positive.

Publication of country-specific estimates

UNAIDS aims to publish estimates for all countries with populations of 250 000 or more. For the countries with populations of 250 000 or more that did not submit estimates, UNAIDS developed estimates using the Spectrum software that were based on published or otherwise available information. These estimates contributed to regional and global totals but were not included in our reports or website.

In countries with low-level epidemics, the number of pregnant women living with HIV is difficult to estimate. Many women living with HIV in these countries are sex workers, people who use drugs or sexual partners of people who use drugs or gay men or other men who have sex with men, and thus they are likely to have different fertility levels than the general population. UNAIDS does not present estimates of mother-to-child HIV transmission or estimates related to children infected with HIV through mother-to-child transmission in some countries with concentrated epidemics unless adequate data are available to validate these estimates.

With regard to reporting incidence trends, if there are not enough historical data to confidently state whether a decline in incidence has occurred, UNAIDS will not publish earlier data to avoid users making inaccurate inferences about trends. Specifically, incidence trends are not published if there are fewer than four data points for the key population or if there have been no data for the past four years.

Finally, in a few instances, UNAIDS will not publish country estimates when further data or analyses are needed to produce valid estimates. More information on the UNAIDS estimates and the individual Spectrum files for most countries can be found on the UNAIDS website (www.unaids.org)