Part 1. Methods for deriving UNAIDS HIV estimates

Introduction

UNAIDS annually provides revised global, regional and country-specific modelled estimates using the best available epidemiological and programmatic data to track the HIV epidemic. 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: doing so would require regularly testing every person for HIV 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 of describing 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 are primarily comprised of monitoring and evaluation specialists, programme officers, epidemiologists, demographers and others from the national ministry of health, national AIDS bodies and technical partners.

The software used to produce the estimates is Spectrum (developed by Avenir Health) with additional models that interact with Spectrum to estimate HIV incidence.[1] The UNAIDS Reference Group on Estimates, Modelling and Projections provides technical guidance on the development of the HIV component of the software.[2]

A brief description of methods used by UNAIDS to create estimates[3]

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 pregnant women attending antenatal clinics and from nationally representative population-based surveys. Many countries have historically conducted HIV sentinel surveillance among women attending antenatal clinics, which requires collecting data from a selection of clinics for a few months every few years. More recently, a number of countries have stopped conducting sentinel surveillance among pregnant women and are now using the data from the routine HIV tests conducted when pregnant women attend antenatal clinics and are tested for HIV. These data avoid the need to conduct a separate surveillance effort, and they provide a complete set of data from all clinics across the country instead of samples from specific sites.

The trends from pregnant women at antenatal clinics, whether done through surveillance or routine data, can be used to inform estimates of 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 estimates of national HIV prevalence levels. Data from these surveys also contribute to estimating age- and sex-specific HIV prevalence and incidence levels and trends. 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. HIV prevalence trends 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 (e.g., at the level of the province or state) 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.

1 More information on Avenir Health can be found at www.avenirhealth.org.
2 For more on the UNAIDS Reference Group on Estimates, Modelling and Projections, please visit www.epidem.org.
3 A set of articles describing the methods is available in a 2019 supplement (Volume 33, Supplement 3) of the journal AIDS: https://journals.lww.com/aidsonline/toc/2019/12153.

In the remaining countries, where HIV transmission occurs largely among key populations at higher risk of HIV and the epidemic can be described as low-level, the estimates are derived from either surveillance among key populations and the general, low-risk population, or from HIV case reporting data, depending on which data are most reliable in a particular country. In countries with high-quality HIV surveillance data among the key populations, the data from repeated HIV prevalence studies that are focused on key populations are used to derive national estimates and trends. Estimates of the size of key populations are increasingly derived empirically in each country; when studies are not available, they are derived based on regional values and consensus among experts. Other data sources—including HIV case reporting data, population-based surveys and surveillance among pregnant women—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 most countries in western and central Europe and North America—and many countries in Latin America, the Caribbean, and the Middle East and North Africa that have insufficient HIV surveillance or survey data, but that have robust disease reporting systems—HIV case reporting and AIDS-related mortality data from vital registration systems are used to 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 people living with HIV, people newly infected with HIV, people dying from AIDS-related illness and other important indicators (including treatment 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 United Nations Population Division's *World population prospects 2019* data files or recent census data.

Selected inputs into the model—including the number of people on antiretroviral therapy and the number of women accessing services to prevent the vertical transmission of HIV—are reviewed and validated in partnership with the United Nations Children's Fund (UNICEF), the World Health Organization (WHO), the Government of the United States of America, the Global Fund to Fight AIDS, Tuberculosis and Malaria (the Global Fund), 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.

In 2020, subnational estimates were created and used by 39 countries in sub-Saharan Africa. The methods for creating these subnational estimates are provided in Part 4 of this annex.

Uncertainty bounds around UNAIDS estimates

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

In countries using HIV surveillance data, the quantity and source of the available data 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. Countries producing subnational estimates at the provincial level have wider ranges. 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 assumptions required to arrive at the estimate also contribute 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 prevalence among pregnant women and the probability of mother-to-child HIV transmission that have their own additional uncertainty.

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 included in the 2020 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 or antiretroviral therapy coverage rates, including for past years. Second, improvements are incorporated into the model based on the latest available science and statistical methods, which leads to the creation of more accurate trends in HIV incidence. Occasionally, countries will also change the incidence modeling option within Spectrum based on improvements in the data available in the country. Due to these improvements to the model and the addition of new data to create the estimates, the results from previous years cannot be compared with the results from this year. A full historical set of estimates are created each year, however, enabling a description of trends over time.

Between the 2019 estimates and the 2020 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.

Breastfeeding among women living with HIV

In 2020, a new option was added to allow countries to enter antiretroviral therapy drop-off rates for breastfeeding women during the first year of breastfeeding and for 12 or more months. This reflects research showing that the first year of breastfeeding had higher drop-out levels than subsequent years *(1)*.

In addition, the patterns of breastfeeding duration for women living with HIV were updated. In previous versions of the software, data from a recent population-based survey informed the distribution of breastfeeding duration. In the 2020 model, however, the distribution was improved to use a distribution from the region by HIV status of the woman to improve the accuracy of those estimates.

Changes to case surveillance and vital registration model

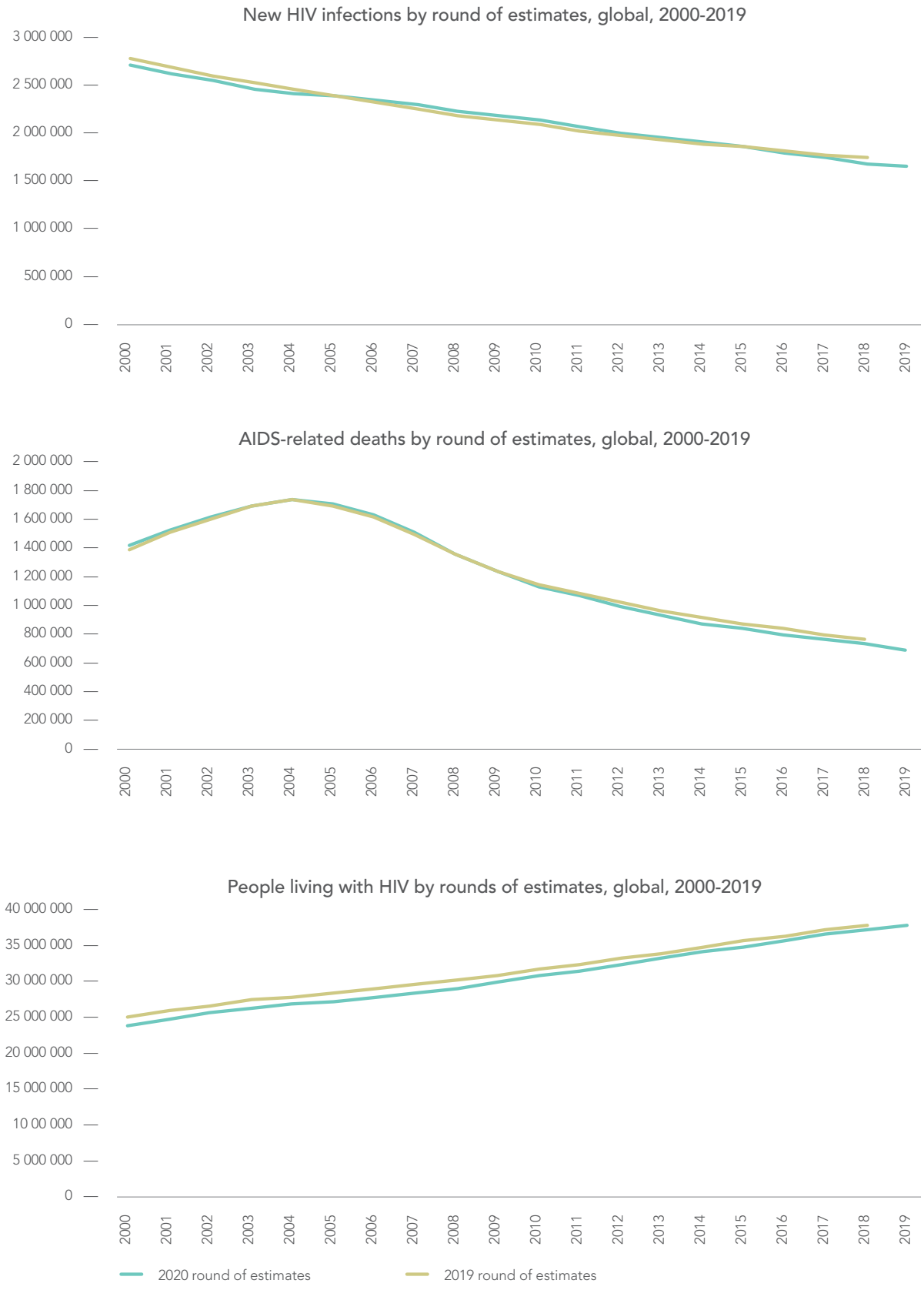
Under the technical guidance of the UNAIDS Reference Group on Estimates, Modelling and Projections, the Case Surveillance and Vital Registration model fitting tool was modified to fit to age- and sex-specific new diagnosis and mortality data. The option to fit to CD4 count data at the time of diagnosis from case surveillance systems was dropped from the model, while additional analyses are being conducted to assess the utility of these data.

Revisions to the HIV diagnosis model were made to permit a more flexible diagnosis rate, which included an initial "pulse" of HIV testing and a "second wave" of HIV testing that follows a logistic curve, as well as the addition of HIV testing driven by opportunistic infections. Finally, fitting approaches using the double logistic and spline curve fitting were modified to improve curve fits.

At the global level, trends in new HIV infections, AIDS-related deaths and people living with HIV are similar to the 2019 round, although there are shifts within regions.

FIGURE 05.03

Comparison of 2019 to 2020 UNAIDS estimates: new HIV infections, AIDS-related deaths and people living with HIV, global, 2000-2019



Source: UNAIDS 2020 and 2019 epidemiological estimates

Publication of country-specific estimates

UNAIDS aims to publish estimates for all countries with populations of 250 000 or more (according to the United Nations Population Division *World population prospects 2019*. For the countries with populations of 250 000 or more that did not submit estimates, UNAIDS developed estimates using the Spectrum software based on published or otherwise available information. These estimates contributed to regional and global totals, but they were not published as country-specific estimates.

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 or people who use drugs—or they are the sexual partners of people who use drugs or gay men and other men who have sex with men—making them likely to have different fertility levels than the general population. UNAIDS does not present estimates of mother-to-child HIV transmission, including estimates related to children in some countries that have concentrated epidemics, unless adequate data are available to validate these estimates. UNAIDS also does not publish estimates related to children for countries where the estimated number of pregnant women living with HIV is less than 50.

With regard to reporting incidence trends, if there are not enough historical data to state with confidence whether a decline in incidence has occurred, UNAIDS will only publish data for the most recent year. This is done to prevent users from 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 for countries using repeated survey or routine testing data. Trends prior to 2000 are not published for countries using case surveillance models if there are no early case surveillance or mortality data available.

Finally, UNAIDS does not publish country estimates when further data or analyses are needed to produce justifiable 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). Data from the estimates can be found in the AIDSinfo section of the UNAIDS website (http://aidsinfo.unaids.org).

Part 2. Methods for deriving the 90–90–90 targets

Introduction

Since 2015, UNAIDS has reported estimates of global, regional and country-specific progress against the 90–90–90 targets. Progress toward these targets is monitored using three basic indicators:

- Indicator 1 (the first 90): The percentage of people living with HIV who know their HIV status.
- Indicator 2 (the second 90): The percentage of people living with HIV who know their status and are accessing treatment.
- Indicator 3 (the third 90): The percentage of people living with HIV on treatment who have suppressed viral loads.

Indicators 2 and 3 can also be expressed as a percentage of all people living with HIV. When numbers or coverage of the treatment target are expressed relative to the total number of people living with HIV, this is called "the HIV testing and treatment cascade." Annual estimates of antiretroviral therapy coverage among people living with HIV are available from the time when treatment was first introduced in countries.

Data sources for constructing country measures

Country-level progress against the 90–90–90 targets was constructed using reported data from Spectrum, the Global AIDS Monitoring tool and (for selected countries in western and central Europe) the Dublin Declaration monitoring process. Estimates are published for all people and separately for children (0 to 14 years) and adults (15 years and older by sex). Upper and lower ranges of uncertainty for country-level estimates were calculated from the range of estimated numbers of people living with HIV. This range may not fully capture uncertainty in the reported estimates.

A description of the target-related indicators that countries report against is provided in the UNAIDS 2019 Global AIDS Monitoring guidelines *(2)*. Data sources are also briefly described. A summary of the number of countries that are publicly reporting on each measure is provided in Table 05.01, organized by region.

The final set of country measures of progress against the 90–90–90 targets for 2015 through 2019 are available at http://aidsinfo.unaids.org. Not all countries were able to report against all three prongs of the 90–90–90 targets: complete treatment cascades are published for 60 countries, the same as in the previous round.

Estimates of people living with HIV

All progress measures in this report are based on UNAIDS global, regional and country-specific modelled estimates from Spectrum of the numbers of people living with HIV. Estimates of people living with HIV are developed for all countries with populations above 250 000. More details about how UNAIDS derives estimates and uncertainty bounds around the number of people living with HIV can be found in Part 1 of this annex.

Estimates of people living with HIV in 2019 were available for 170 of 194 countries and territories and they were published for 122. Published country estimates of people living with HIV (available at http://aidsinfo.unaids.org) represent 80% of the total global estimated number of people living with HIV in 2019.

Knowledge of HIV status among people living with HIV

Estimates of the number of people living with HIV who know their status were derived using the most recent HIV surveillance, programme data and nationally representative population-based survey data. Where data were available separately for children (aged 0–14 years) and adults (aged 15 years and older, by sex), the age- and sex-specific measures were first calculated and then aggregated to produce a national measure.

For countries outside of eastern and southern Africa and western and central Africa, published estimates of the number of people living with HIV who knew their HIV status are based on HIV surveillance case notification data, programme registers or modelled estimates derived from case surveillance data. If the estimate from these

sources was lower than the number of people accessing antiretroviral therapy, the reported value was excluded. For countries using HIV surveillance or programme data, a country should have included this measure only if the HIV surveillance system had been functioning since at least 2014 and people who have died, emigrated or have otherwise been lost to follow-up are removed.

Although HIV surveillance systems, including those based on programme registers, can be a reasonably robust source of data to estimate the number of people living with HIV who know their status, biases in the reported numbers may still exist. For example, a country's measure of the knowledge of status may be underestimated if not all people diagnosed are reported to the surveillance system in a timely manner. The measure also may be overestimated if people are reported to the system or included on a register more than once and these duplicates are not detected. Similarly, if people die or emigrate but are not removed from the system, the number of people living with HIV who are reported to know their HIV status also will be overstated.

For most countries in eastern and southern Africa and western and central Africa, estimates of the numbers of people living with HIV who knew their status were derived using the UNAIDS-supported mathematical model Shiny90. This model uses population-based survey and HIV testing service programme data—together with country-specific HIV epidemic parameters from the standard UNAIDS Spectrum model—to produce outputs of knowledge of HIV status for adults, by sex. More details on the modelling approach are available elsewhere *(3)*.

Knowledge of HIV status from the Shiny90 model for eastern and southern Africa and western and Central Africa has a number of strengths compared with other approaches that rely directly on population survey data and programme treatment coverage data. Most importantly, the Shiny90 model uses population survey data to estimate the proportion of people living with HIV who report ever having an HIV test who are aware of their HIV status and those who likely seroconverted after their last HIV-negative test. This distinction is informed by the national incidence trend calculated in Spectrum and is consistent with national published estimates of HIV prevalence and reported antiretroviral therapy coverage. The Shiny90 tool also uses assumptions from Spectrum and the population survey data to estimate knowledge of status by sex and age, assuming male-to-female testing ratios have remained relatively constant over time. Estimates of knowledge of status are also available since 2010.

An important model limitation, similar to other estimation approaches, is that caution should be used in interpreting results in instances when the last population-based survey was conducted more than five years ago, or if there are concerns about the accuracy of self-reported testing history in the survey. Countries can include HIV testing data from HIV programmes to improve trends in years where the population survey data are not available. Another limitation is that model results are only for those aged 15 years and older. UNAIDS continues to recommend that countries conservatively estimate knowledge of status among children as the proportion of children living with HIV on treatment (unless other information from case surveillance data are available).

People accessing antiretroviral therapy

Global and regional measures of antiretroviral therapy numbers are abstracted from country-reported programme data through the UNAIDS-supported Spectrum software, the Global AIDS Monitoring reporting tool and the Dublin Declaration reporting process. In the 2020 round, 118 countries publicly reported treatment numbers, and between 2015 and 2019, 144 countries had at least one publicly available estimate of the number of people on treatment (representing 85% of all people on treatment). For the small number of countries where reported numbers of people on treatment are not available in selected years—primarily in western and central Europe and North America, and in China, India and the Russian Federation—estimates of the number of people on treatment are developed either in consultation with the public health agency responsible for monitoring the national treatment programme or based on published and unpublished sources.

In partnership with UNICEF, WHO, the United States Government, the Global Fund and other partners that support treatment service delivery in countries, UNAIDS annually reviews and validates treatment numbers that countries have reported

to UNAIDS through Global AIDS Monitoring and Spectrum. UNAIDS staff also provide technical assistance and training to country public health and clinical officers to ensure the quality of the treatment data reported. Nevertheless, this measure may overestimate the number of people on treatment if people who transfer from one facility to another are reported by both facilities. Similarly, coverage may be overestimated if people who have died, disengaged from care or emigrated are not identified and removed from treatment registries. Treatment numbers also may be underestimated if not all clinics report the numbers on treatment completely or in a timely manner.

In 2016, UNAIDS completed a triangulation of data to verify the UNAIDS global estimate of people accessing antiretroviral therapy at the end of 2015. Since early 2017, UNAIDS and other international partners have supported more than 15 countries, primarily in sub-Saharan Africa, to verify that the number of people reported to be currently on treatment is accurate. For more details about how confident UNAIDS is in reported treatment numbers, please see *How many people living with HIV access treatment?* [4]

People who have achieved viral suppression

Progress towards the viral suppression target among people on treatment and as a proportion of all people living with HIV was derived from data reported in Spectrum and through the online Global AIDS Monitoring reporting tool and the Dublin Declaration reporting process. For the purposes of reporting, the threshold for suppression is a viral load of less than 1000 copies per ml. Some countries may set lower thresholds or require persons to achieve an undetectable viral load, and where these lower thresholds are reported by a country, an estimate of the number of people who would have been suppressed at 1000 copies per ml is added to the number reported to be suppressed at the lower threshold. The Global AIDS Monitoring guidance describes this adjustment in more detail. This guidance also specifies that only a person's last test result from the reporting year should be submitted, so the reported number suppressed among those tested should represent people and not tests performed.[5]

UNAIDS 2019 Global AIDS Monitoring guidelines were revised from those of 2018 to clarify that countries should report viral load suppression outcomes, regardless of testing coverage. However, viral load testing results will only be published in countries where access to testing is nationally representative of all people on treatment (typically 50% or higher testing coverage). Table 1 shows the increase in the number of countries able to report on viral load suppression compared to previous years. In 2015, only 29 countries had reliable estimates; in 2019, there were 70 countries with reported data.

4 The document is available at http://www.unaids.org/en/resources/documents/2016/how-many-people-living-with-HIV-access-treatment.
5 This document is available at https://www.unaids.org/sites/default/files/media_asset/global-aids-monitoring_en.pdf

TABLE 05.01

Data availability for constructing UNAIDS measures of progress against the 90–90–90 targets, 2015–2019

		Asia and the Pacific	Caribbean	Eastern and southern Africa	Eastern Europe and central Asia	Latin America	Middle East and North Africa	Western and central Africa	Western and central Europe and North America	Global
Number of countries		38	16	16	21	17	20	25	40	193
Number of countries in UNAIDS global estimates		28	10	20	16	17	19	24	36	170
Number of countries with publicly available data on estimates of people living with HIV	2015	18	7	20	12	14	13	24	11	119
	2016	18	7	20	12	14	13	24	11	119
	2017	18	7	20	12	14	13	24	11	119
	2018	18	7	20	12	14	13	24	11	119
	2019	18	7	20	12	14	13	24	10	118
Number of countries with publicly available data on knowledge of HIV status	2015	8	6	18	9	5	7	22	15	90
	2016	10	6	19	9	7	7	22	19	99
	2017	11	6	19	9	8	7	22	23	105
	2018	11	6	19	10	9	8	22	19	104
	2019	11	6	20	10	10	7	23	6	93
Number of countries with publicly available data on treatment	2015	22	9	20	15	17	17	24	20	144
	2016	22	9	20	13	17	17	24	19	141
	2017	23	9	20	14	17	18	24	17	142
	2018	21	9	20	13	16	16	24	14	133
	2019	18	7	20	12	15	13	24	9	118
Number of countries with publicly available data on people with suppressed viral load	2015	6	2	3	6	4	3	1	4	29
	2016	6	4	8	6	8	4	2	8	46
	2017	7	6	6	9	10	6	3	7	54
	2018	8	8	14	9	9	7	7	8	70
	2019	9	7	18	12	7	6	6	5	70

Source: UNAIDS special analysis, 2020.

For countries with nationally representative but not universal access to viral suppression testing, the estimate of viral suppression among those tested (i.e., the third 90) was multiplied by the number of people on treatment to obtain overall viral suppression levels in the country.

A number of challenges exist in using country-reported data to monitor the viral load suppression target. First, routine viral load testing may not be offered at all treatment facilities, and those facilities that do offer it may not be representative of the care available at facilities without viral load testing. Since it is not possible to know for certain suppression in the untested population, we assume that the percentage of people suppressed among those accessing viral load testing is representative of all people on treatment.

Another challenge in measuring the accuracy of viral load suppression estimates is that UNAIDS

guidance requests routine (e.g., annual) viral load testing results only for people who are on treatment and eligible for testing. If people newly initiated on treatment achieve viral suppression but have not yet been offered viral load testing, they will be incorrectly counted as not suppressed, and the resulting viral suppression estimate will be understated. UNAIDS also requests countries to only report results from routine viral load testing: if countries report test results primarily performed because of suspected treatment failure, the number of people virally suppressed in these countries will be underestimated. UNAIDS validates country submissions for quality, but it is not always possible to identify cases where both routine and other types of testing are occurring.

Finally, UNAIDS guidance recommends reporting viral load test results only for people on antiretroviral therapy; persons who are not on treatment and who naturally suppress the virus will not be included in this measure.

Methods for constructing the 90–90–90 treatment target at the regional and global levels

All programme data submitted to UNAIDS were validated by UNAIDS and its partners prior to publication. Country-submitted data that did not meet the required validation checks for quality either at the indicator level or across the treatment cascade were not included in the composite regional or global measures.

To estimate regional and global progress against the 90–90–90 targets, UNAIDS imputed missing country data for the first and third 90 targets using a Bayesian hierarchical model with uncertainty based on regional trends, sex differences and country-specific data for those countries reporting data for some but not all years. Estimates are available by sex for adults 15 years and older from 2015 to 2019. As in previous years, results of global and regional progress towards the 90–90–90 targets presented in this report supersede all previously published estimates. Additional details on the modelling approach are available elsewhere *(5)*.

The proportion of estimates of knowledge of status and viral load suppression imputed by region from 2015 to 2019 to account for countries with missing data are shown in Table 2. Due to large differences in the proportion of virally suppressed people in western and central Europe and the United States for the years in which data were available, subregional estimates were separately calculated for North America and western and central Europe and then combined to estimate the western and central Europe and North America regional results at large. Upper and lower ranges of uncertainty around the global and regional estimates of the HIV testing and treatment cascade are provided that reflect uncertainty in the number of people living with HIV and uncertainty (from missing country data) in the number of people who know their HIV status and the number of people who are virally suppressed. Based on reports from data quality reviews through 2019, uncertainty from possible overreporting or underreporting of treatment numbers was added to the bounds of treatment coverage among people living with HIV and the second and third 90s. Upper and lower ranges of uncertainty for the 90s do not capture uncertainty in the reported or missing programme data on the numbers of people who know their HIV status or the number of people on treatment who are virally suppressed.

One primary limitation that arises from incomplete availability of country estimates is that it is difficult to quantify the extent to which progress in countries that reported data to UNAIDS is similar to that of countries in the region that do not have data. This is particularly true for viral load suppression estimates, where reported data in some regions—especially in 2015 and 2016—are limited. For example, viral load testing coverage in western and central Africa was especially low between 2015 and 2017, with most estimates derived from countries reporting data in 2018 and 2019. In Asia and the Pacific, national-level estimates of viral load suppression are not available in any year for India and not prior to 2018 for China. In western and central Europe and North America, HIV testing and treatment reporting, including viral load suppression through the Dublin Declaration, was suspended due to the COVID-19 pandemic, and the last reported estimate of viral load suppression by the United States at the time of this report was 2016.

TABLE 05.02

Proportion of imputed data of the number of people living with HIV who know their status and the number of people living with HIV on treatment who are virally suppressed, 2015–2019

		Asia and the Pacific	Caribbean	Eastern and southern Africa	Eastern Europe and central Asia	Latin America	Middle East and North Africa	Western and central Africa	Western and central Europe and North America	Global
Estimates of people living with HIV where knowledge of status is imputed (%)	2015	84	15	0	8	27	29	0	30	17
	2016	83	15	0	8	23	30	0	13	16
	2017	23	15	0	7	19	31	0	29	7
	2018	49	15	0	6	13	27	0	39	11
	2019	79	16	0	2	58	34	0	97	21
Estimates of people living with HIV on treatment where viral suppression is imputed (%)	2015	83	91	57	76	31	63	99	18	63
	2016	84	88	33	9	28	59	99	2	47
	2017	85	56	47	7	17	42	91	92	61
	2018	14	2	25	5	24	41	63	96	33
	2019	73	14	1	4	28	45	87	98	31

Source: UNAIDS special analysis, 2020.

Part 3. Data on key populations

Distribution of new HIV infections by subpopulation

The distribution of new HIV infections among subpopulations globally and by region was estimated based on data for 170 countries using four data sources.

The underlying number of new infections for each country is estimated with Spectrum. New infections among men and women aged 15 to 49 years are used.

For countries that model their HIV epidemic based on data from subpopulations, including key populations, the numbers of new infections were extracted from Spectrum 2020 files. This source provided data for sex workers from 60 countries, for people who inject drugs from 37 countries, for gay men and other men who have sex with men from 62 countries, and for transgender people from 20 countries (all of which were located in Latin America, the Caribbean, and Asia and the Pacific). Additionally, 18 countries (mostly from Asia and the Pacific) had data from clients of sex workers.

New HIV infections for western and central European countries were derived from European Centre for Disease Prevention and Control (ECDC) and WHO Regional Office for Europe HIV/AIDS surveillance in Europe 2019 (2018 data) *(6)*. The proportions of new diagnoses for each region in Europe (western, central and eastern) were applied to UNAIDS estimates of new infections in each country for people who inject drugs, gay men and other men who have sex with men, and transgender people. Data for sex workers were not available from the ECDC report. New HIV infections in China, India, the Russian Federation and the United States were taken from the most recent available national reports of new diagnoses or other published sources.

New HIV infections among countries without a direct data source were calculated from regional benchmarks. The benchmarks were set by the median proportion of new infections in the specific subpopulation in all available countries in the same region. The majority of these countries were

located in sub-Saharan Africa. There were 115 countries that used benchmark values for the sex worker estimate, 97 countries for the people who inject drugs estimate, 72 countries for the gay men and other men who have sex with men estimate, and 143 countries for the transgender people estimate.

New infections among sex partners of key populations were estimated using the number of sex partners and transmission probabilities from the literature. These include non-injecting sex partners of people who inject drugs, female sex partners of gay men and other men who have sex with men, spouses/steady sexual partners of sex workers, clients of sex workers and the clients' spouses/steady sex partners.

Quality of population size estimates

Population size estimates are used to calculate the relative risks presented in this report. The Global AIDS Monitoring system collects population size estimates. Some of the submitted size estimates are considered subnational, and UNAIDS uses regional medians of the population proportions of submitted size estimates to fill in missing information or extrapolate from subnational estimates.

The regional sections of this report include tables on the estimated size of key populations. These data are based on values reported through Global AIDS Monitoring in 2019. A comprehensive review of the data was conducted during this reporting round, and estimates therefore should not be compared with data presented in previous UNAIDS reports. As a result of this process, the estimates reported can be categorized as follows:

- "National population size estimate" refers to estimates that are empirically derived using one of the following methods: multiplier, capture–recapture, mapping/enumeration, network scale up method (NSUM) or population-based survey, or respondent-driven sampling-successive sampling (RDS-SS). Estimates had to be national or a combination of multiple sites with a clear approach to extrapolating to a national estimate.
- "Local population size estimate" refers to estimates that are empirically derived using one of the previously mentioned methods, but only for a subnational group of sites that are insufficient for national extrapolation.
- "Insufficient data" refers either to estimates derived from expert opinions, Delphi, wisdom of crowds, programmatic results or registry, regional benchmarks or unknown methods, or estimates derived prior to 2010. Estimates may or may not be national.

Part 4. Subnational HIV estimates for sub-Saharan Africa and the Caribbean

Subnational HIV estimates were generated for 39 countries in sub-Saharan Africa and Haiti in the Caribbean. The indicator displayed in Figure 1.11 is the incidence of HIV infection among females aged 15 to 24 years by subnational level.

Two methods were used to generate the subnational estimates: the Naomi model was used by 20 countries (19 in sub-Saharan Africa and Haiti), while a simpler district disaggregation method was used for 18 other countries in sub-Saharan Africa (see Table 05:04).

Naomi model: This model uses small area estimation to jointly model HIV prevalence and people living with HIV, antiretroviral therapy coverage and HIV incidence. The model combines subnational-level data about multiple outcomes from several sources in a Bayesian statistical model. It uses national population-based survey data and antiretroviral therapy and antenatal clinic testing service provision data to provide robust indicators of subnational HIV burden. It provides estimates and uncertainty ranges for a number of indicators (including HIV prevalence, people living with HIV, antiretroviral therapy coverage, HIV incidence and new infections) by sex, five-year age groups and subnational level.

The model produces estimates at three time points: the year of the most recent population-based survey, the year of the last round of HIV national estimates (2019), and short-term, one-year projections for HIV programme planning purposes. Subnational population estimates by sex and age group are sourced from consensus sources in each country and adjusted to match the populations used within Spectrum by sex and age group.

Cross-sectional estimates for HIV prevalence, antiretroviral therapy coverage and HIV incidence are produced at the mid-point of the most recent nationally representative household survey. For HIV prevalence, the model is calibrated to survey data on HIV prevalence by subnational level, sex and five-year age group from the most recent population-based survey (Demographic and Health Survey or Population HIV Impact Assessment). Since the survey sample size in each district is relatively small, routinely reported data about HIV prevalence among pregnant women attending their first antenatal care visit, extracted from the national health information system, are used to improve estimates of the spatial pattern of HIV.

Antiretroviral therapy coverage by district, age and sex is estimated from population-based survey data about the presence of antiretroviral biomarkers in HIV-positive survey respondents. Routinely reported antiretroviral therapy coverage among pregnant women prior to their first antenatal care visit is used as a covariate for the spatial pattern of antiretroviral therapy coverage. The antiretroviral therapy coverage and HIV prevalence are also calibrated so that the total number on antiretroviral therapy matches that report in the Spectrum national file.

A challenge for estimating treatment coverage at the district level is that persons may access antiretroviral therapy services in a different district than their residence (for instance, if facilities are closer or felt to provide better services). The model allows for a probability that resident people living with HIV access antiretroviral therapy in a neighbouring district. The prior assumption is that the large majority of people living with HIV will access antiretroviral therapy in their district of residence, but this probability can vary based on district data about the number of people receiving antiretroviral therapy compared to HIV prevalence, antiretroviral therapy coverage and population.

Direct estimates of HIV incidence are not available at the subnational levels. While some recent household surveys have measured HIV incidence at the national level based on biomarker measures for recent HIV infections, too few recent infections are observed in any district to make a robust estimate. Therefore, to estimate HIV incidence at the subnational level, the HIV transmission rate from Spectrum estimates is calculated and applied to small area estimates of HIV prevalence and antiretroviral therapy coverage in each subnational area. The sex and age distribution in each

subnational area is based on HIV incidence rate ratios from Spectrum applied to the population structure in each area.

The model projects from the most recent household survey to the current period by creating a one-step projection of the population to 2019. Population estimates are updated with official population estimates. The number of people living with HIV is projected forward based on survival estimates by province, sex and age group from Spectrum over the same period (which accounts for HIV disease progression and the effects of antiretroviral therapy scale-up on reducing AIDS mortality). Antiretroviral therapy coverage is updated based on the number on treatment in 2019 from service provision data.

District disaggregation method: A tool was used to obtain subnational estimates for people living with HIV and new infections by disaggregating the national HIV estimates from the national Spectrum file. The disaggregation was done based on the distribution of people living with HIV aged 15 to 49 years and the subnational total population data provided by the national HIV estimates team. To produce these estimates, the tool requires inputs on the population aged 15 to 49 years, and HIV prevalence among people aged 15 to 49 years by subnational area. The tool first calculates the proportion of people living with HIV aged 15 to 49 years at the national level that are in each district. These proportions are then used to disaggregate other indicators calculated in the Spectrum file. The same distributions are applied to any age and sex group.

The incidence rate among young women aged 15 to 24 years was calculated as follows:

New infections among females aged 15 to 24 years in 2019 / (population of females aged 15 to 24 years – HIV-positive females aged 15 to 24 years) in 2019 * 1000

TABLE 05.04

Method used for subnational HIV estimates

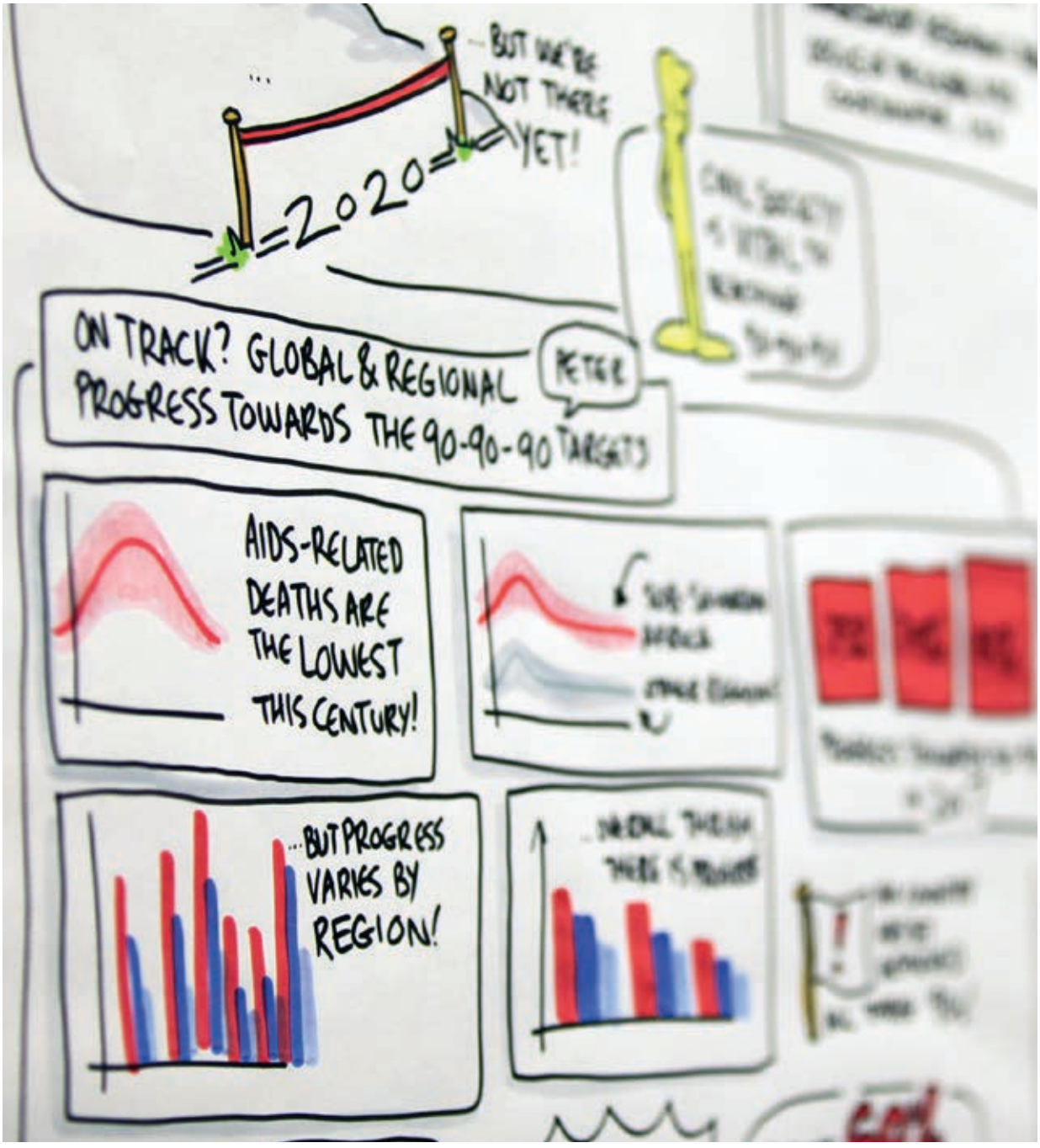
No.	Country	Subnational method
1	Angola	District tool
2	Benin	District tool
3	Botswana	District tool
4	Central African Republic	District tool
5	Chad	District tool
6	Congo	District tool
7	Equatorial Guinea	District tool
8	Eritrea	District tool
9	Gabon	District tool
10	Gambia	District tool
11	Ghana	District tool
12	Guinea	District tool
13	Guinea Bissau	District tool
14	Liberia	District tool
15	Mali	District tool
16	Niger	District tool
17	Sierra Leone	District tool
18	South Sudan	District tool
19	Burkina Faso	Naomi
20	Burundi	Naomi
21	Cameroon	Naomi
22	Côte d'Ivoire	Naomi
23	Democratic Republic of the Congo	Naomi
24	Eswatini	Naomi
25	Ethiopia	Naomi
26	Haiti	Naomi
27	Kenya	Naomi
28	Lesotho	Naomi
29	Malawi	Naomi
30	Mozambique	Naomi
31	Namibia	Naomi
32	Nigeria	Naomi
33	Rwanda	Naomi
34	South Africa	Naomi
35	Togo	Naomi
36	Uganda	Naomi
37	United Republic of Tanzania	Naomi
38	Zambia	Naomi
39	Zimbabwe	Naomi

Part 5. Laws and policies scorecards

The regional laws and policies scorecards were constructed based on data reported by countries through the 2017, 2018 and 2019 National Commitments and Policy Instrument, a component of Global AIDS Monitoring *(2)*.

Data submitted by countries through the National Commitments and Policy Instrument are reviewed by UNAIDS. During this review process, UNAIDS liaises with national Global AIDS Monitoring focal points to request clarification or to revise data submitted through the tool.

Data reported through the National Commitments and Policy Instrument have been complemented with data available from other sources, including global databases and primary sources.



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