

Methods

Methods for deriving UNAIDS HIV estimates

Introduction

Every year UNAIDS 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 not possible 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 infeasible and ethically problematic. Modelled estimates—and the lower and upper bounds around these estimates—provide a rigorous representation of the HIV pandemic in terms of levels and trends.

Country teams use UNAIDS-supported software to develop estimates annually. The country teams are comprised primarily of national monitoring and evaluation specialists, programme officers, epidemiologists, demographers and other experts from the national ministry of health, national AIDS bodies and technical partners.

The software used to produce the estimates is Spectrum (developed by Avenir Health¹) and its AIDS Impact Model (AIM). Most countries use an incidence model that runs within the AIM module of Spectrum. A few countries use an external model whose incidence estimate is imported into AIM (Table A2.1). The UNAIDS Reference Group on Estimates, Modelling and Projections² provides technical guidance on the development of the AIM module in Spectrum.

¹ www.avenirhealth.org

² www.epidem.org

Table A2.1 Incidence models used for national HIV estimates collated in the Spectrum software and UNAIDS 2023 estimation round

INCIDENCE MODEL	COUNTRIES	HIV PREVALENCE (AMONG PEOPLE AGED 15–49 YEARS) (MEDIAN)	REGIONS
Estimation and Projection Package (EPP), generalized epidemic	38	1.9%	<ul style="list-style-type: none"> • Asia and the Pacific • Caribbean • Eastern and southern Africa • Western and central Africa
EPP, concentrated epidemic	37	0.31%	<ul style="list-style-type: none"> • Asia and the Pacific • Caribbean • Eastern Europe and central Asia • Latin America • Middle East and North Africa
AIDS Epidemic Model	13	0.33%	<ul style="list-style-type: none"> • Asia and the Pacific
Case Surveillance and Vital Registration (CSAVR) or European Centre for Disease Prevention and Control (ECDC) model, fitting deaths or case reports	72	0.12%	<ul style="list-style-type: none"> • Asia and the Pacific • Caribbean • Eastern Europe and central Asia • Latin America • Middle East and North Africa • Western and central Europe and North America
Other	12	0.28%	<ul style="list-style-type: none"> • Asia and the Pacific • Eastern and southern Africa • Latin America • Western and central Europe and North America
All models	172	0.3%	

Methods and models used by UNAIDS and countries to create estimates³

Countries where HIV transmission sustains an epidemic in the general population use the Estimation and Projection Package (EPP) module of the Spectrum modelling tool, which fits a trend to HIV prevalence data 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. In recent years, most countries have stopped conducting sentinel surveillance among pregnant women and are now using 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 selected sites.

The trends from pregnant women at antenatal clinics, whether measured 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 include men and ensure coverage of all people, regardless of whether they use health-care services—are representative of national HIV prevalence levels and, if

³ The methods are described in detail in Volume 33 (Suppl 3) of AIDS (2019); and Advancing methods for global HIV estimates. Maheu-Giroux M, Ciaranello AL, Salomon JA, Sohn AH, guest editors. J Int AIDS Soc. 2021;24(S5).

repeated, also inform trends. Data from these surveys also contribute to estimating age- and sex-specific HIV prevalence and incidence levels and trends. A few countries in sub-Saharan Africa that have not conducted population-based surveys adjusted HIV prevalence levels based on comparisons of antenatal clinic surveillance and population-based survey data from other countries in the region. The resulting HIV prevalence trends, in addition to numbers of people on antiretroviral therapy, are then used to estimate the national HIV incidence trend, accounting for effects of antiretroviral therapy on survival.

Countries where HIV transmission occurs largely among people from key populations at higher risk of HIV and the epidemic is low-level or concentrated use the AIDS Epidemic Model—a variant of the EPP model that fits to high-quality surveillance prevalence data and population size estimates for each of several key populations and the lower-risk general population.

To estimate HIV prevalence in the remaining lower-risk general population, these countries generally input surveillance data from pregnant women and account for people who cease behaviours that put them at increased risk for HIV acquisition—for example, women who cease selling sex will be included among the remaining population of people living with HIV. The resulting HIV prevalence curve and number of people on antiretroviral therapy are then used to derive a national HIV incidence trend.

Most countries in western and central Europe and North America use AIDS-related mortality data from vital registration and HIV case reports and the delay from infection to diagnosis to estimate national HIV prevalence and incidence trends. These countries use the Case Surveillance and Vital Registration (CSAVR) model within Spectrum, or the European Centre for Disease Prevention and Control (ECDC) model or, in a few instances, a country-specific model. The CSAVR model is also used by some countries in Latin America, the Caribbean, and the Middle East and North Africa that have robust disease reporting systems but limited HIV surveillance or survey data.

All countries that use UNAIDS-supported methods for their estimates share common assumptions about the effectiveness of HIV treatment and disease progression by sex and age. These assumptions are based on systematic literature reviews and meta-analyses of study data by scientific experts.

Demographic population data, including fertility, mortality and migration, are derived from the United Nations Population Division World Population Prospects 2022 estimates or recent census data and reflect the de facto population (current residents, regardless of nationality) of each country.

Country teams update the data in their Spectrum files every year with the latest available data on numbers of people receiving antiretroviral therapy, pregnant women receiving antiretroviral therapy, and HIV surveillance data, among other data. The model is run and results are reviewed by country teams before sharing with UNAIDS.

Final country-submitted files containing the modelled outputs are reviewed at UNAIDS to ensure results are comparable across regions and countries and over time. Selected inputs into the model—including numbers of people on antiretroviral therapy and numbers of women accessing services to prevent vertical transmission of HIV—are further reviewed and validated in partnership with the United Nations Children’s Fund (UNICEF), the World Health Organization (WHO), the United States President’s Emergency Plan for AIDS Relief (PEPFAR) and its agencies, the Global Fund to Fight AIDS, Tuberculosis and Malaria (Global Fund), and other partners.

In the 2023 round of estimates, subnational estimates were created and used by 38 countries (37 in sub-Saharan Africa, one in the Caribbean). Methods for creating these subnational estimates are described later in 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 in 95% of cases (if it could be measured). Narrow bounds indicate that an estimate is precise, while wide bounds indicate greater uncertainty regarding the estimate, given the data and assumptions.

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 one or more national population-based surveys have 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 determine 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 and people who have died from AIDS-related causes lie within the reported ranges. With more years of good-quality surveillance data over successive estimation rounds, the uncertainty on a country’s estimate will typically decrease.

Improvements included in the 2023 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 new science and statistical methods, which lead to the creation of more accurate trends in HIV incidence. Occasionally, countries change the incidence modelling 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 estimation rounds cannot be compared with the results from the current round. Full historical estimates are created at each round, however, and these enable evaluation of trends over time.

Between the 2022 and 2023 estimates, the following key changes were made to the models, following guidance from the UNAIDS Reference Group on Estimates, Modelling and Projections.

Demographic projection

The underlying demographic data are now based on the World Population Prospects 2022 version, replacing the 2019 version. This update was accepted in most countries except where a country had evidence to use other demographic sources. Associated with this update, Spectrum results for a given point in time were aligned with the World Population Prospects to represent the end of December instead of mid-year as done in previous rounds. Spectrum results for a year were adjusted to represent the period from January through December instead of July through June.

Impact of antiretroviral therapy on HIV transmission

Before the 2023 round of estimates, the reduction in HIV transmission from people on treatment was a fixed assumption for all countries (0.80 for each percentage point increase in adult antiretroviral therapy coverage). In the 2023 software, the impact of treatment on transmission is based on each country's viral load suppression data (over the most recent three years), with a stronger reduction in transmission for countries with higher viral load suppression (within a plausible range of 0.70–0.93).

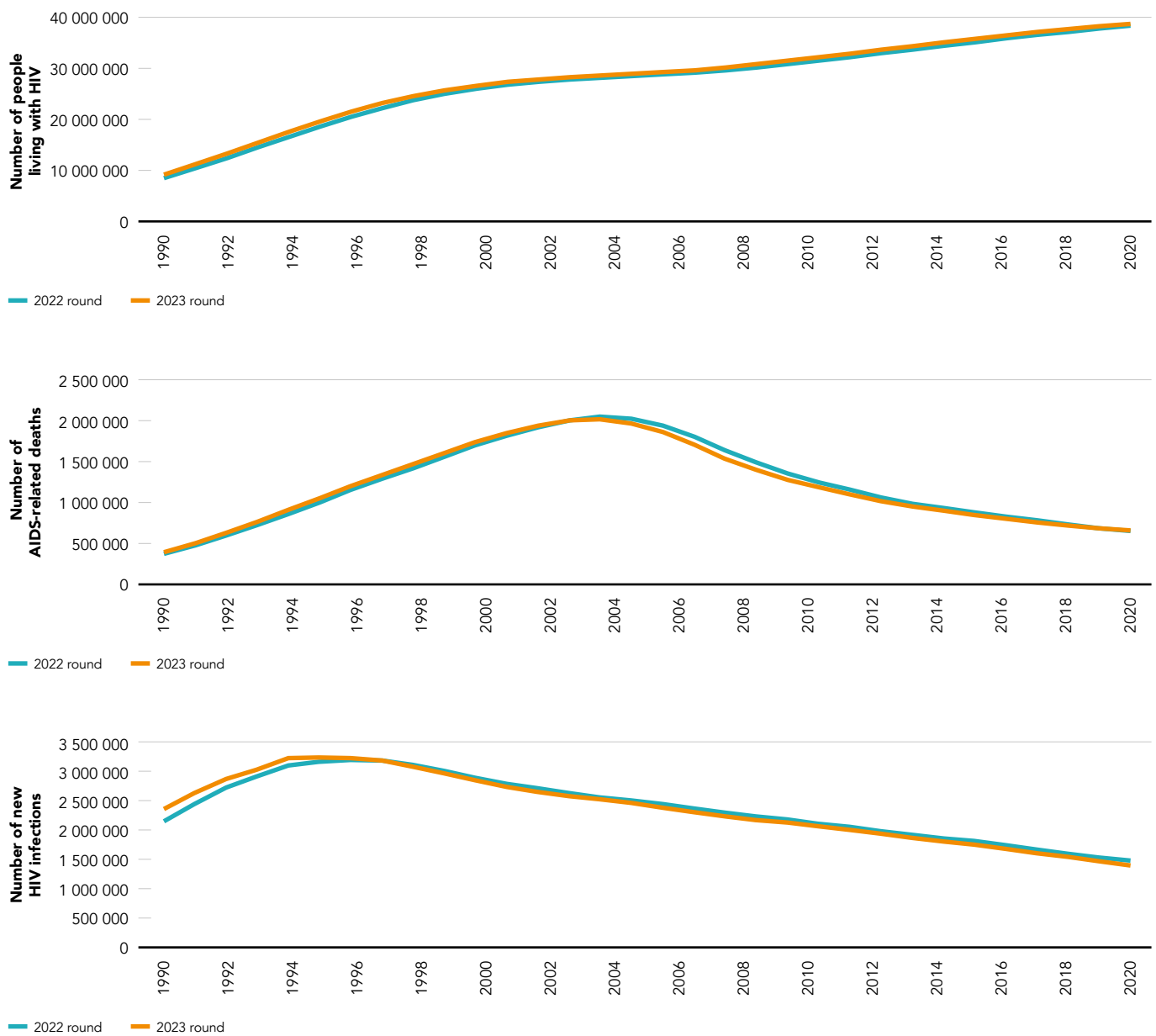
Mortality among adults on antiretroviral therapy

For high-income countries, the default AIDS-related mortality rates assumed for people on treatment, notably in the category of CD4>500/mL, were reduced to match good-quality cause-of-death data (from leDEA

multi-site cohort analyses). For Asia and the Pacific, conversely, default rates were increased, such that these two groups of countries now have similar survival patterns in Spectrum.

Figure A2.1 presents the 2023 estimates compared with the 2022 estimates. Shifts in the curves are the combined effect of the updated country data and the changes to model structure and assumptions described above. At the global level, trends in numbers of new HIV infections, AIDS-related deaths and people living with HIV are like those estimated in the preceding round, although there are shifts within some regions.

Figure A2.1 Comparison of 2022 and 2023 UNAIDS estimates: people living with HIV, AIDS-related deaths and new HIV infections, global, 1990–2022



Source: UNAIDS epidemiological estimates, 2022 and 2023 rounds.

Publication of country-specific estimates

UNAIDS aims to publish estimates for all countries with populations of 250 000 or more people (according to the United Nations Population Division World Population Prospects 2022). For countries with populations of 250 000 or more people 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 were not published as country estimates on AIDSinfo.

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, gay men and other men who have sex with men, or sex workers—with possibly different fertility levels than the general population. UNAIDS therefore does not present estimates of vertical HIV transmission or child infections in many countries with concentrated epidemics, unless adequate data are available to inform these estimates. Estimates related to children are not published for countries where the estimated number of pregnant women living with HIV is fewer than 50.

If there are not enough historical data to determine incidence trends, UNAIDS does not publish historical incidence:

- EPP-based incidence trends are published only if there are four or more data points and prevalence data in the past four years for the most important subpopulation.
- For low-level epidemics that rely on case and death surveillance data, incidence trends are published if the input data include at least eight data points on both AIDS-related deaths and new HIV diagnoses within 1990–2022. These incidence estimates are anchored in a back-calculation from reported AIDS-related deaths, and they are not highly sensitive to decreases in testing volumes and new diagnoses that some countries experienced in 2020 or 2021 due to COVID-19-related health service disruptions. Nevertheless, some countries that use an incidence model anchored in case reporting postponed estimates for 2021 and 2022 to address potential COVID-related biases.

In the 2023 round, incidence was not published for seven of 138 countries that published estimated numbers of people living with HIV (and 135 countries that published estimated numbers of adults living with HIV). For another five countries, incidence was published up to 2020 or 2021 only.

UNAIDS does not publish country estimates when available data are insufficient to justify the estimate. In the 2023 round, estimates were not published for 23 countries, either because of insufficient data or because of no country submission.

More information on the UNAIDS estimates and the individual Spectrum files for most countries can be found at <http://hivtools.unaids.org>. Data from the estimates can be found at <http://aidsinfo.unaids.org>.

Methods for deriving the 95–95–95 testing and treatment targets

Introduction

Since 2015, UNAIDS has reported estimates of global, regional and country-specific progress against the testing and treatment targets. In the United Nations Political Declaration on HIV and AIDS: Ending Inequalities and Getting on Track to End AIDS by 2030, testing and treatment targets were set to reach 95–95–95. These targets refer to three indicators:

- Indicator 1 (the first 95): the percentage of people living with HIV who know their HIV status.
- Indicator 2 (the second 95): the percentage of people living with HIV who know their HIV status and are accessing treatment.
- Indicator 3 (the third 95): 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 total numbers of people living with HIV, this is called the HIV testing and treatment cascade.

Data sources for constructing country measures

Country-level progress against the 95–95–95 targets was constructed using reported data from Spectrum and Global AIDS Monitoring. Estimates are published for all people and separately for children (aged 0–14 years), men (aged 15+ years) and women (aged 15+ years). Corresponding upper and lower bounds were based on uncertainty ranges on estimated numbers of people living with HIV for each country, population group and year. These target-related indicators and their data sources are described in the UNAIDS Global AIDS Monitoring 2023 guidelines (1).

Table A2.2 Data available for constructing UNAIDS measures of progress against the 95–95–95 targets, 2015–2022

NUMBER	YEAR	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
Countries		39	16	21	16	17	19	25	39	193
Countries in UNAIDS global estimates		29	10	20	16	17	19	25	36	172
Countries with published estimate of adults living with HIV in 2022		22	10	19	11	16	16	24	20	135
Countries with publicly available data on adults living with HIV who know their HIV status	2015	13	9	16	12	8	14	22	12	106
	2016	16	9	16	12	10	14	22	19	118
	2017	18	9	16	12	11	14	22	19	121
	2018	20	9	16	12	12	14	22	23	128
	2019	20	9	16	12	12	14	22	21	126
	2020	20	9	16	12	12	14	22	19	124
	2021	19	9	16	12	12	14	22	18	122
	2022	17	8	16	12	11	15	22	12	113
Countries with publicly available data on adults living with HIV who are on treatment	2015	24	10	19	12	15	19	24	26	149
	2016	24	10	19	12	15	19	24	26	149
	2017	24	10	19	12	15	19	24	26	149
	2018	24	10	19	12	15	19	24	25	148
	2019	24	10	19	12	15	19	24	24	147
	2020	24	10	19	12	15	19	24	22	145
	2021	23	10	19	12	15	19	24	19	141
	2022	22	10	19	12	13	18	24	11	129
Countries with publicly available data on adults living with HIV who were tested for viral load and found to be virally suppressed	2015	4	2	3	5	6	7		7	34
	2016	5	4	6	6	9	8		11	49
	2017	7	8	7	9	10	9	1	13	64
	2018	10	9	12	10	12	10	4	16	83
	2019	13	9	17	11	11	8	7	15	91
	2020	13	8	16	11	11	8	8	15	90
	2021	12	8	15	10	12	9	10	13	89
	2022	12	8	16	11	12	10	10	8	87

Source: UNAIDS epidemiological estimates, 2015–2022.

Note: not counting some countries that published numbers of adults living with HIV who knew their status or were on treatment but missing a corresponding estimate of total numbers of adults living with HIV.

Table A2.2 summarizes the number of countries that have reported each measure in each region over the past eight years.

The final set of country measures of progress against the 95–95–95 targets for 2015 through 2022 are available at <http://aidsinfo.unaids.org>. Not all countries were able to report against all three targets. In the 2023 estimates round, complete treatment cascades for 2023 were published for 79 countries, an increase from 68 countries in the 2022 estimates round.

Estimates of people living with HIV

All progress measures in this report are based on national estimates of people living with HIV that used the Spectrum model. In the 2023 round, people living with HIV were estimated for 172 of 193 countries and territories. These 172 countries represent 99% of the total global population. Estimates of adults living with HIV were published for 135 of these 172 countries.

Knowledge of HIV status among people living with HIV

Numbers of people living with HIV who know their HIV status were estimated over time using HIV case 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, by sex), age- and sex-specific measures were calculated and then aggregated to national measures.

Countries outside of sub-Saharan Africa without national household surveys estimated the number of people living with HIV who knew their HIV status based on HIV case notification data and programme registers. Some concentrated epidemic countries used notification data directly, if their HIV surveillance system had been functioning since 2015 or longer and they were able to subtract from cumulative diagnosed people those who had died, emigrated or were otherwise lost to follow-up. If this calculation estimated the number of people with HIV who knew their HIV status as fewer than those on antiretroviral therapy, however, the reported value was excluded, as it was potentially incorrect due to one of several common biases. For example, a country may underestimate the number of people living with HIV who are aware of their HIV status if not all people diagnosed are reported to the surveillance system in a timely manner. Conversely, the measure is overestimated if people are registered or reported more than once and such duplicates are not detected, or if people die or emigrate but are not removed from the system. Such overestimation of the number of people living with HIV who are aware of their HIV status was common before 2015.

Alternatively, concentrated epidemic countries could estimate knowledge of status as part of their overall epidemic estimation through the CSAVR model, which estimated incidence of infection, knowledge of status and antiretroviral therapy coverage from case and death notifications.

Most countries in eastern and southern Africa and western and central Africa estimated knowledge of status in adults using the UNAIDS-supported Shiny90 tool (2), which is part of the Spectrum software. This mathematical model fits data from national population-based surveys on proportions of respondents living with and without HIV who had ever tested for HIV, in addition to HIV testing services programme data on the annual number of HIV tests conducted and the number of positive tests, and Spectrum model results (2).

Knowledge of HIV status estimates from Shiny90 have strengths over those drawn directly from population surveys or programme records. By constructing the population's HIV incidence and testing history over time, the resulting trend in HIV status awareness is adjusted for known reporting biases in awareness of HIV status in household surveys and accounts for retesting and repeat diagnoses among routine programme data on annual HIV diagnoses (3, 4). The Shiny90 estimates distinguish people living with HIV who had an HIV test after seroconversion and so are aware of their HIV status from those who seroconverted after their last HIV-negative test. The distinction is informed by the national incidence trend calculated in Spectrum. Shiny90 estimates knowledge of status by sex and age, assuming adult male/female testing rate ratios have remained relatively constant since 2010. Results include additional indicators such as the percentage of people diagnosed within a year and the number of people (by HIV status) retesting.

Caution is warranted with knowledge of status estimates if 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.

Both Shiny90 and the CSAVR estimate of knowledge of HIV status only cover adults aged 15 years and older. UNAIDS recommends that countries conservatively estimate knowledge of status among children as the proportion of children living with HIV on treatment, unless reliable numbers from case surveillance (cumulative diagnoses and deaths, emigrations and losses to follow-up) are available.

People accessing antiretroviral therapy

Global and regional measures of antiretroviral therapy numbers are calculated from data entered by country teams into the Spectrum software or the Global AIDS Monitoring reporting tool. In the 2023 round, 129 countries reported treatment numbers for 2022 (covering 82% of the estimated people on treatment). Between 2015 and 2022, 159 countries had at least one publicly available estimate of the number of people on treatment. For a few countries that did not report numbers of people on treatment for all years—primarily high-income countries in western and central Europe and North America, and Asia and the Pacific—people on treatment were estimated either in consultation with the public health agency responsible for monitoring the national treatment programme or from published and online sources.

In partnership with UNICEF, WHO, PEPFAR and its agencies, 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. The number of people on treatment may be overestimated if people who transfer from one facility to another are reported by both facilities, or if people who have died, disengaged from care or emigrated are not identified and removed from treatment registries. Conversely, treatment numbers are sometimes underestimated if not all clinics report the numbers of people on treatment completely or in a timely manner.

UNAIDS and other international partners support countries to verify the accuracy of numbers of people reported to be currently on treatment.

People who have achieved viral suppression

Progress towards the viral suppression target among people on treatment and as a percentage of all people living with HIV was estimated from data reported in Spectrum and through the Global AIDS Monitoring reporting tool. For the purpose of reporting, the threshold for suppression is a viral load below 1000 copies/mL. Some countries set lower thresholds to identify a person as having achieved an undetectable viral load. Where a country uses a lower threshold, Spectrum applies an adjustment to estimate the percentage suppressed at 1000 copies/mL. The Global AIDS Monitoring guidance describes this adjustment in detail. The guidance also specifies that only routine viral load tests should be reported and only a person's last test result from the reporting year should be submitted, so reported numbers represent people tested and suppressed rather than tests performed (1).

Countries are asked to report viral load suppression outcomes for all years, regardless of testing coverage. However, UNAIDS publishes viral load testing results only for countries and for each year where at least 50% of people treated are tested for viral load. For countries and years with nationally representative but not universal viral suppression data, the reported proportion suppressed among people tested for viral load (the third 95) was multiplied by the total number of people on treatment to estimate overall viral suppression numbers.

Table A2.3 shows numbers of countries with a reliable estimate of viral load suppression. This increased from 64 countries in 2017 to 87 countries by 2022. Some countries had lower viral load testing coverage for 2020 or 2021 compared with 2019 or 2022, often due to the COVID-19 pandemic and related disruptions or delays in health service provision and reporting.

Some 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. The facilities that do the test may not be representative of facilities without viral load testing. Despite this uncertainty, we assume that the percentage of people suppressed among those accessing viral load testing is representative of all people on treatment.

Second, UNAIDS requests countries to only report results from routine viral load testing. If countries report test results primarily performed because of suspected treatment failure, then 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.

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

Methods for constructing regional and global results towards the 95–95–95 targets

All programme data submitted to UNAIDS were validated by UNAIDS and its partners before publication. Country-submitted data that did not meet quality standards, either at the indicator level or across the treatment cascade, were not included in the calculation of regional or global estimates. These included, for example, viral load suppression results for years when less than 50% of people on treatment were tested for viral load.

To estimate regional and global progress against the 95–95–95 targets for adults, UNAIDS imputed missing country data for the first and third 95 targets using a Bayesian hierarchical model. This uses regional trends—or global trends, when regional trends are sparse—sex differences and patterns over time from countries with good-quality data and coherent cascade estimates. Upper and lower bounds around global and regional estimates of the HIV testing and treatment cascade reflect uncertainty in the number of people living with HIV and uncertainty from missing country data in numbers of people who know their HIV status or who are virally suppressed. These ranges do not capture uncertainty in country-reported people who know their HIV status, were tested for viral load or are virally suppressed. Details on the model's methods and assumptions are available elsewhere (5).

Table A2.3 shows the proportions of people living with HIV for whom knowledge of HIV status and viral load suppression were imputed, as opposed to reported or estimated by the country, from 2015 to 2022. Generally, the proportion imputed decreased over time, as more countries reported good-quality data. Some regions (e.g. Asia and the Pacific, western and central Europe and North America) have an increased proportion of countries with imputed knowledge of status or viral load suppression in 2022 compared with earlier years, as the latest data were still being reviewed.

Some countries are still not able to report on the testing and treatment cascade or elements of the cascade. Although the percentage of people tested for viral load has increased in many countries, knowledge of status remains difficult to estimate, especially in countries without population-based surveys that measure HIV serostatus alongside respondents' testing history. Limited data are available to inform knowledge of status in Asia and the Pacific, western and central Europe and North America, and Latin America.

Table A2.3 Proportion of estimated people living with HIV for whom knowledge of status was imputed, and proportion of estimated people on treatment for whom viral suppression was imputed, 2015–2022

INDICATOR	YEAR	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
Proportion of estimated people living with HIV for whom knowledge of status was imputed	2015	24	4	<0.02	3	11	8	–	24	5
	2016	23	4	<0.02	2	9	7	–	2	4
	2017	24	3	<0.02	2	5	7	–	13	4
	2018	14	3	–	2	2	7	–	7	2
	2019	15	3	–	2	2	7	–	16	3
	2020	43	3	–	2	1	6	–	66	9
	2021	43	3	–	2	1	4	–	23	7
	2022	37	3	–	2	8	2	–	80	9
Proportion of estimated people on treatment for whom viral suppression status was imputed	2015	62	44	25	50	15	23	51	20	31
	2016	61	21	18	5	14	22	51	9	26
	2017	60	1	12	4	8	23	42	13	20
	2018	31	1	0	3	8	13	8	17	6
	2019	34	1	0	2	9	13	7	6	6
	2020	4	0	0	2	5	6	1	54	4
	2021	1	0	0	2	5	4	1	27	2
	2022	1	1	0	0	12	3	0	77	4

Source: UNAIDS epidemiological estimates, 2016–2022.

New infections among key populations

New HIV infections by subpopulation

New HIV infections among key populations globally and by region were estimated for 172 countries for the years 2010 and 2022. Multiple sources were synthesized to estimate the numbers of new infections among key populations within each country's overall Spectrum estimate of new infections among men and women aged 15–49 years.

For some countries that modelled their historic HIV epidemic based on data from subpopulations including one or more key populations using the EPP-concentrated or Aids Epidemic Model (6) or Thembisa (7), new infection trends among key populations were extracted from Spectrum 2023 estimates. This source provided data for sex workers from 33 countries, for people who inject drugs from 20 countries, for gay men and other men who have sex with men from 33 countries, and for transgender people from 24 countries (in Latin America, the Caribbean, western and central Europe and North America, Asia and the Pacific, the Middle East and North Africa, and South Africa).

For most countries in sub-Saharan Africa, and in other countries without a national Spectrum model including all key populations, estimates from the Goals (8) and Optima (9, 10) transmission dynamics and programme impact models were used. These were calibrated to country-owned 2023 Spectrum models for overall epidemic trends, and results were standardized to these by importing proportions (not numbers) of overall adult infections in each key population. Goals- and Optima-estimated proportions of adult infections were also used to estimate new infections among clients of female sex workers and non-client, non-key population male and female sex partners of people from key populations to complement national estimates of key populations where available.

For countries without a national epidemic model that distinguished key populations, proportions of new infections were approximated from proportions of national new adult case diagnoses if recorded by mode of transmission. This was done for most countries in western and central Europe, and for countries with strong case-based HIV surveillance in eastern Europe and central Asia, Latin America, the Caribbean, and Asia and the Pacific. In these countries, as a proxy for new infection estimates in 2010 we used diagnoses reported in 2012 and 2013, while new infections in 2022 were inferred from diagnoses from 2019–2022, depending on each country's data availability (11).

Some models and some case surveillance systems did not cover all key populations or clients and partner groups. For these, new infections were approximated using median proportions of infections in the group across countries within the region with an estimate. This helped to complete estimates notably for transgender people, clients of sex workers, and other sex partners of people from key populations.

Sex partners were considered to include non-injecting sex partners of people who inject drugs, female sex partners of gay men and other men who have sex with men, and spouses and steady sex partners of sex workers.

This is the first year UNAIDS has estimated trends in new HIV infections among key populations from 2010, the baseline of the global AIDS strategy, through 2022. The analysis is limited by missing data on some or all key populations from many countries. Results should be interpreted as indicating broad patterns and trends rather than precise estimates. For this reason, the results presented focus on proportional changes over time in new infections among each group rather than on underlying numbers of infection or distributions.

Compared with earlier published estimates of distributions, the new estimated proportions of new infections among key populations are lower. This mainly reflects a change from using outdated static models such as modes of transmission and incidence patterns analyses mostly conducted more than a decade ago, to using transmission-dynamic models.

A technical report with details of the refined multi-source estimation methods and updated results is under development.

Calculation of pre-exposure prophylaxis (PrEP) coverage for HIV-negative people

Global and regional PrEP targets for gay men and other men who have sex with men, people who inject drugs, and transgender people were set by the UNAIDS Target Setting Group, with support from Avenir Health. Targets were established using available data on the size of key populations and their relative vulnerability for 118 countries. Additional country targets were included to reach a maximum of 166 countries for gay men and other men who have sex with men, 123 for people who inject drugs and 132 for transgender people (12).

Global and regional PrEP targets for sex workers were calculated for 184 countries based on the population size estimates reported through Global AIDS Monitoring in recent years, from which sex workers living with HIV were subtracted. Each size estimate was categorized regarding recency, geographical location and methods adequacy using the criteria described previously (13). Nationally adequate estimates were used to determine median proportions among adults (aged 15–49 years) for each UNAIDS region. The regional median proportions were used to calculate country-specific values that were summed to regional total size estimates. The number of people living with HIV by country was calculated by multiplying the most recently reported HIV prevalence (2018–2022) through Global AIDS Monitoring to each country's population size estimate. For countries that did not report HIV prevalence among sex workers in recent years, a regional median prevalence was applied. The PrEP target for sex workers was calculated by subtracting regional numbers of sex workers living with HIV from the total estimated number of sex workers in the region.

For all key populations, current PrEP coverage was estimated using nationally reported PrEP use for the specific key population (number of people who received any PrEP product at least once during the reporting period) divided by the size of the population that would benefit from PrEP use.

Quality of population size estimates

The regional sections of this report include tables of the estimated size of key populations. The estimated size of key populations refers to reported values through Global AIDS Monitoring since 2018 only. A comprehensive review of the data was conducted during these reporting rounds, and therefore estimates should not be compared with data presented in previous UNAIDS reports. Submitted estimates are reviewed as they are reported and categorized for appropriate use. The categories are as follows:

- National population size estimate refers to estimates that have been empirically derived since 2018 using one of the following methods: multiplier, capture–recapture, mapping/enumeration, network scale-up method, population-based survey, or respondent-driven

sampling successive sampling. Estimates must be national or from a combination of multiple sites with a clear approach to extrapolating to a national estimate.

- Local population size estimate refers to estimates that have been empirically derived since 2018 using one of the previously mentioned methods, but only for subnational 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 to estimates derived before 2018. Estimates may or may not be national.

Subnational HIV estimates for sub-Saharan Africa

Subnational HIV estimates were generated using the Naomi model for 37 countries in sub-Saharan Africa and one in the Caribbean that had conducted one or more representative population-based serosurveys (see Table A2.4).

The Naomi model uses small area estimation to jointly model HIV prevalence and people living with HIV, antiretroviral therapy coverage and HIV incidence (14). 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 data to provide robust indicators of subnational HIV burden. It provides estimates and uncertainty ranges for several 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 (2022), and short-term 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 midpoint 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-based HIV Impact Assessment). Since the survey sample size in each subnational area 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 subnational area, age and sex is estimated from population-based survey data about the presence of antiretroviral biomarkers in survey respondents living with HIV. Routinely reported antiretroviral therapy coverage among pregnant women before 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 calibrated so that the total number of people on antiretroviral therapy matches the report in the Spectrum national file.

A challenge for estimating treatment coverage for subnational areas is that people may access antiretroviral therapy services in a different district from their residence (e.g. if facilities are closer or perceived to provide better services). The model allows for a probability that people living with HIV access antiretroviral therapy in a neighbouring subnational area. The prior assumption was that most people living with HIV will access antiretroviral therapy in their area of residence, but this probability can vary based on subnational area data about the number of people receiving antiretroviral therapy compared with HIV prevalence, antiretroviral therapy coverage and population.

Direct estimates of HIV incidence are not available at the subnational level. Although 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 are based on incidence rate ratios from a country's national Spectrum file, 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 2022. 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 coverage reducing AIDS-related mortality). Antiretroviral therapy coverage is updated based on the number of people on treatment in 2022 from service provision data.

Table A2.4 Countries using the Naomi model to generate subnational estimates

COUNTRY	COUNTRY
Angola	Haiti
Benin	Kenya
Botswana	Lesotho
Burkina Faso	Liberia
Burundi	Malawi
Cameroon	Mali
Central African Republic	Mozambique
Chad	Namibia
Congo	Niger
Côte d'Ivoire	Rwanda
Democratic Republic of the Congo	Sao Tome and Principe
Equatorial Guinea	Senegal
Eswatini	Sierra Leone
Ethiopia	South Africa
Gabon	Togo
Gambia	Uganda
Ghana	United Republic of Tanzania
Guinea	Zambia
Guinea-Bissau	Zimbabwe

Estimates of HIV risk group proportions for adolescent girls and young women

The occurrence of HIV risk behaviours and associated HIV incidence at subnational levels among adolescent girls and young women was estimated for 30 countries in sub-Saharan Africa (15). Geospatially referenced national household survey data from 1999–2019 across 30 countries in sub-Saharan Africa were analysed. Female survey respondents aged 15–24 years were classified into four risk groups (not sexually active, cohabiting, non-regular or multiple partner(s), and female sex workers) based on reported sexual behaviours in a Bayesian spatiotemporal multinomial regression model to estimate the proportion of adolescent girls and young women in each risk group stratified by district, year and five-year age group. Estimates of HIV prevalence and incidence at subnational levels from the Naomi model were used along with incidence rate ratios for each risk group to estimate the number of new infections and incidence rate for each district, age and risk population.

Laws and policies scorecards

The regional laws and policies scorecards were constructed based on validated data reported by countries through the National Commitments and Policy Instrument, a component of Global AIDS Monitoring (1), between 2017 and 2022 and complementary sources, including national legal and policy documents and other global databases.

Data submitted by countries through the National Commitments and Policy Instrument are reviewed by UNAIDS. During this review process, information reported are compared with available primary sources and other related publicly available information. UNAIDS also liaises with national Global AIDS Monitoring focal points to request clarification or 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 primary sources and other global databases.

UNAIDS regional definitions

The regional definitions for Asia and the Pacific and the Middle East and North Africa changed in 2022, with the Islamic Republic of Iran being moved from the Middle East and North Africa to Asia and the Pacific. All presentations of data, including historic trends, now use this new regional definition.

ASIA AND THE PACIFIC

Afghanistan
Australia
Bangladesh
Bhutan
Brunei Darussalam
Cambodia
China
Democratic People's Republic of Korea
Fiji
India
Indonesia
Iran (Islamic Republic of)
Japan
Lao People's Democratic Republic
Malaysia
Maldives

Mongolia
Myanmar
Nepal
New Zealand
Pakistan
Papua New Guinea
Philippines
Republic of Korea
Singapore
Sri Lanka
Thailand
Timor-Leste
Viet Nam

CARIBBEAN

Bahamas
Barbados
Belize

Cuba
Dominican Republic
Guyana
Haiti
Jamaica
Suriname
Trinidad and Tobago

EASTERN AND SOUTHERN AFRICA

Angola
Botswana
Comoros
Eritrea
Eswatini
Ethiopia
Kenya
Lesotho
Madagascar

Malawi
Mauritius
Mozambique
Namibia
Rwanda
South Africa
South Sudan
Uganda
United Republic of Tanzania
Zambia
Zimbabwe

EASTERN EUROPE AND CENTRAL ASIA

Albania
Armenia
Azerbaijan
Belarus
Bosnia and Herzegovina
Georgia
Kazakhstan
Kyrgyzstan
Montenegro
North Macedonia
Republic of Moldova
Russian Federation
Tajikistan
Turkmenistan
Ukraine
Uzbekistan

LATIN AMERICA

Argentina
Bolivia (Plurinational State of)
Brazil
Chile
Colombia
Costa Rica
Ecuador
El Salvador
Guatemala
Honduras
Mexico
Nicaragua
Panama
Paraguay
Peru
Uruguay
Venezuela (Bolivarian Republic of)

MIDDLE EAST AND NORTH AFRICA

Algeria
Bahrain

Djibouti
Egypt
Iraq
Jordan
Kuwait
Lebanon
Libya
Morocco
Oman
Qatar
Saudi Arabia
Somalia
Sudan
Syrian Arab Republic
Tunisia
United Arab Emirates
Yemen

WESTERN AND CENTRAL AFRICA

Benin
Burkina Faso
Burundi
Cabo Verde
Cameroon
Central African Republic
Chad
Congo
Côte d'Ivoire
Democratic Republic of the Congo
Equatorial Guinea
Gabon
Gambia
Ghana
Guinea
Guinea-Bissau
Liberia
Mali
Mauritania
Niger
Nigeria
Sao Tome and Principe
Senegal
Sierra Leone
Togo

WESTERN AND CENTRAL EUROPE AND NORTH AMERICA

Austria
Belgium
Bulgaria
Canada

Croatia
Cyprus
Czechia
Denmark
Estonia
Finland
France
Germany
Greece
Hungary
Iceland
Ireland
Israel
Italy
Latvia
Lithuania
Luxembourg
Malta
Netherlands
Norway
Poland
Portugal
Romania
Serbia
Slovakia
Slovenia
Spain
Sweden
Switzerland
Turkey
United Kingdom of Great Britain and Northern Ireland
United States of America

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