Global, regional, and national incidence, prevalence, and mortality of HIV, 1980–2017, and forecasts to 2030, for 195 countries and territories: a systematic analysis for the Global Burden of Diseases, Injuries, and Risk Factors Study 2017

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Global, regional, and national incidence, prevalence, and mortality of HIV, 1980–2017, and forecasts to 2030, for 195 countries and territories: a systematic analysis for the Global Burden of Diseases, Injuries, and Risk Factors Study 2017

GBD 2017 HIV collaborators*

Summary

Background Understanding the patterns of HIV/AIDS epidemics is crucial to tracking and monitoring the progress of prevention and control efforts in countries. We provide a comprehensive assessment of the levels and trends of HIV/AIDS incidence, prevalence, mortality, and coverage of antiretroviral therapy (ART) for 1980–2017 and forecast these estimates to 2030 for 195 countries and territories.

Methods We determined a modelling strategy for each country on the basis of the availability and quality of data. For countries and territories with data from population-based seroprevalence surveys or antenatal care clinics, we estimated prevalence and incidence using an open-source version of the Estimation and Projection Package—a natural history model originally developed by the UNAIDS Reference Group on Estimates, Modelling, and Projections. For countries with cause-specific vital registration data, we corrected data for garbage coding (ie, deaths coded to an intermediate, immediate, or poorly defined cause) and HIV misclassification. We developed a process of cohort incidence bias adjustment to use information on survival and deaths recorded in vital registration to back-calculate HIV incidence. For countries without any representative data on HIV, we produced incidence estimates by pulling information from observed bias in the geographical region. We used a re-coded version of the Spectrum model (a cohort component model that uses rates of disease progression and HIV mortality on and off ART) to produce age-sex-specific incidence, prevalence, and mortality, and treatment coverage results for all countries, and forecast these measures to 2030 using Spectrum with inputs that were extended on the basis of past trends in treatment scale-up and new infections.

Findings Global HIV mortality peaked in 2006 with 1·95 million deaths (95% uncertainty interval 1·87–2·04) and has since decreased to 0·95 million deaths (0·91–1·01) in 2017. New cases of HIV globally peaked in 1999 (3·16 million, 2·79–3·67) and since then have gradually decreased to 1·94 million (1·63–2·29) in 2017. These trends, along with ART scale-up, have globally resulted in increased prevalence, with 36·8 million (34·8–39·2) people living with HIV in 2017. Prevalence of HIV was highest in southern sub-Saharan Africa in 2017, and countries in the region had ART coverage ranging from 65·7% in Lesotho to 85·7% in eSwatini. Our forecasts showed that 54 countries will meet the UNAIDS target of 81% ART coverage by 2020 and 12 countries are on track to meet 90% ART coverage by 2030. Forecasted results estimate that few countries will meet the UNAIDS 2020 and 2030 mortality and incidence targets.

Interpretation Despite progress in reducing HIV-related mortality over the past decade, slow decreases in incidence, combined with the current context of stagnated funding for related interventions, mean that many countries are not on track to reach the 2020 and 2030 global targets for reduction in incidence and mortality. With a growing population of people living with HIV, it will continue to be a major threat to public health for years to come. The pace of progress needs to be hastened by continuing to expand access to ART and increasing investments in proven HIV prevention initiatives that can be scaled up to have population-level impact.

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Introduction Between 2000 and 2015, excitement around the Millennium Development Goals (MDGs) galvanised more than US$500 billion in spending on prevention, care, and treatment for HIV/AIDS globally.1 Despite the subsequent decrease in overall HIV-related mortality, more than 36 million people still live with HIV/AIDS, which continues to be the underlying cause of death for
Research in context

Evidence before this study
The levels and trends of the global HIV/AIDS epidemic have been estimated by two groups: the Global Burden of Diseases, Injuries, and Risk Factors Study (GBD) and UNAIDS. We searched PubMed with the search terms hiv[MeSH] AND (“mortality” OR “incidence” OR “prevalence”) AND “global” AND (trend”), with no language restrictions, for articles published since database inception until Nov 7, 2018. We did not identify any additional studies that provided comparable evaluations of the global trends in the HIV/AIDS epidemic across countries. The last GBD on HIV was in 2015; however, it did not include assessment of achieving UNAIDS targets using forecasts of past trends and associations in the data.

Added value of this study
For GBD 2017, the main inputs for our estimation of global HIV trends were systematically updated. These updates include a comprehensive update of population estimates that are internally consistent with fertility and mortality estimates for GBD 2017, and incorporate new prevalence data from national surveys and antenatal care clinics. Additionally, we made improvements in our estimation of paediatric HIV via modelling of natural disease progression and incorporating cohort data on child antiretroviral therapy (ART) initiation and mortality. We also better reflected geographical differences in the sex-specific distribution of HIV burden on the basis of a model fit to the sex ratio of prevalence observed in countries with representative surveys. Finally, we used forecasting methods to generate country-level estimates towards achieving global targets related to ART coverage, HIV incidence, and HIV-related mortality by 2020 and 2030.

Implications of all the available evidence
By improving and extending existing HIV/AIDS burden estimates, this study provides valuable insight into progress towards Sustainable Development Goal 3’s target to end the AIDS epidemic by 2030 and the fast-track strategy to do so. Relative to incidence and mortality, more countries are on track to meet ART coverage targets of 81% (90% started, 90% retained) by 2020 and 90% (95% started, 95% retained) by 2030. The relative progress necessary to achieve the 2020 and 2030 targets for reduction in incidence and mortality is not on pace in most countries. Renewed attention and investment in HIV prevention initiatives could help to restore global propensity to meet these targets. This study’s assessment of current trends and progress towards ambitious global targets provides evidence for decision makers to respond to current needs and plan for a future free of HIV/AIDS.

Almost 1 million people every year, concentrated in sub-Saharan Africa. Recognising the sustained threat, UNAIDS set targets for the years 2020 and 2030 with the aim of ending the epidemic by 2030. In this study, we estimate the current and future burden of HIV/AIDS and track progress towards meeting these targets.

Complementing the ambitious Sustainable Development Goal (SDG) to end the HIV/AIDS epidemic by 2030, UNAIDS’ 90-90-90 targets (90% of people living with HIV diagnosed, of whom 90% are on treatment, of whom 90% are virally suppressed) have been set for 2020, and 95-95-95 targets (95% of people living with HIV diagnosed, of whom 95% are on treatment, of whom 95% are virally suppressed) for 2030. In accordance with this fast-track initiative to achieve the SDG goal, UNAIDS has since set targets for reducing the number of HIV incident cases and deaths between 2010 and 2020 by 75% and between 2010 and 2030 by 90% for each country. Although these latest targets have helped to renew focus on the epidemic, measuring patterns in HIV/AIDS incidence, prevalence, and mortality is challenging, in part because of poor vital registration data and incomplete disease notification systems in high-burden areas, and complex disease modelling strategies and methodological limitations. Still, comprehensive global estimates are needed to track progress and understand future burden.

In this Article, we present results from the Global Burden of Diseases, Injuries, and Risk Factors Study (GBD) 2017. We address several methodological and data-related challenges associated with estimating HIV burden to provide a comprehensive and robust assessment of trends in HIV incidence, prevalence, and mortality across 195 countries and territories from 1980 to 2017. Building on previous iterations, we extensively updated population estimates and incorporated new prevalence data from national surveys and antenatal care clinics. Additionally, we generated country-level forecasts towards achieving targets associated with antiretroviral therapy (ART) coverage, HIV incidence, and HIV-related mortality. These forecasts enable us to report country-specific progress towards achieving the following targets: a reduction in the number of HIV incident cases of 75% between 2010 and 2020 and 90% between 2010 and 2030; a reduction in the number of HIV deaths of 75% between 2010 and 2020 and 90% between 2010 and 2030: 81% (90% started, 90% retained) ART coverage by 2020 and 90% (95% started, 95% retained) coverage by 2030.

Methods

Study design and modelling strategy
GBD is a systematic, scientific effort to quantify the comparative magnitude of health loss due to diseases and injuries by age, sex, and geography over time. GBD 2017 includes 195 countries and territories, 16 of which (Brazil, China, Ethiopia, India, Indonesia, Iran, Japan, Kenya, Mexico, New Zealand, Norway, Russia, South Africa,
Sweden, the UK, and the USA] were analysed at the subnational level. The conceptual and analytical framework for GBD, hierarchy of causes, and detailed methods have been published elsewhere. The GBD protocol is also available online. Herein we describe the specific methods used for analysing the burden of HIV for GBD 2017.

Input data for modelling HIV morbidity and mortality include vital registration data, household seroprevalence surveys, data from antenatal care clinics, demographic estimates (population, fertility, migration, and HIV-free survival rates from GBD 2017), intervention coverage data reported to UNAIDS including ART, prevention of mother-to-child transmission, HIV mortality on and off ART, and rates of disease progression from a systematic review (appendix 1 pp 2–4).

The GBD framework for HIV/AIDS aims to produce internally consistent estimates for HIV incidence, prevalence, and mortality and relies on two established estimation models. We used the Estimation and Projection Package (EPP), an HIV epidemic model originally developed by the UNAIDS Reference Group on Estimates, Modelling, and Projections. EPP uses Bayesian methods to infer force of infection from trends in HIV prevalence data. EPP generates incidence and prevalence estimates for individuals aged 15–49 years for both sexes combined. We also used a modified version of Spectrum, a compartmental model used by UNAIDS that ages a population over time while applying HIV incidence, progression, and mortality to produce age-sex-specific HIV incidence, prevalence, and mortality. Both EPP and Spectrum were made for GBD estimation, including developing a model of ART coverage distribution as a function of income, age, sex, and disease progression that we used in Spectrum. Full details of modifications to EPP and Spectrum are in appendix 1 (pp 7–13).

To ensure appropriate modelling techniques, we grouped countries on the basis of availability and quality of data. Group 1 includes countries with HIV prevalence data from antenatal care clinics or representative population-based seroprevalence surveys. Group 1A includes countries with a peak of at least 0·5% prevalence, and group 1B includes countries with a peak of at least 0·25% plus vital registration completeness less than 65%. Group 2 includes all other countries, which are further classified as groups 2A, 2B, and 2C on the basis of availability of vital registration data. Group 2A locations have high-quality data, group 2B locations have at least some data, and group 2C locations have no data on HIV-specific mortality. The modelling framework by country grouping is shown in appendix 1 (pp 5, 6).

This study was approved by the University of Washington Institutional Review Board (application 46665).

Incidence and prevalence estimation

For group 1 countries, we used EPP to estimate incidence and prevalence for individuals aged 15–49 years, for both sexes combined, using population-based surveys and antenatal care clinic data. To account for bias created by the differences in HIV prevalence between pregnant women who attended an antenatal care clinic and the general population, we extracted data from available Demographic and Health Surveys on HIV prevalence among pregnant women who gave birth in the past year and who attended an antenatal care clinic. For antenatal care bias adjustment, we input this data into a regression model with regional random effects to generate country-specific prior distributions where surveys were available and regional prior distributions for locations without a survey. We then used the incidence and prevalence results from EPP as inputs in Spectrum to further disaggregate to age-sex-specific HIV incidence and prevalence. We used the sex ratio of prevalence from population-based surveys to inform the sex-splitting assumptions for adults in Spectrum, and applied default age-splitting assumptions from Spectrum. We calculated vertical transmission as a function of prevention of mother-to-child transmission inputs and age-specific fertility rates adjusted to account for differential fertility among women who were HIV positive.

For group 2 countries, we developed a process called cohort incidence bias adjustment to estimate incidence and prevalence using mortality data. We ran a first stage of Spectrum to generate initial incidence, prevalence, and mortality curves, along with incidence cohort survival. We then calculated the bias between Spectrum mortality estimates and smoothed vital registration data for each year, which we used along with Spectrum cohort survival estimates to adjust incidence (appendix 1 pp 11–13). To account for sensitivity in our estimates to input incidence, we ran the first stage of Spectrum using various input incidence curves and selected the option with the smallest resulting bias in mortality estimates. We ran a second stage of Spectrum using adjusted incidence to produce age-sex-specific incidence and prevalence estimates. In countries with high-quality case notification data, we scaled incidence results to align with case reports after accounting for an assumed average of 5 years’ lag between infection and diagnosis.

Mortality estimation

We undertook a meta-analysis of cohort studies to derive on-ART and off-ART mortality as inputs into Spectrum and EPP. We estimated age-sex-specific, CD4-specific, region-specific, and duration-specific on-ART mortality using cohort data after correcting for loss to follow-up (appendix 1 pp 4–7). We jointly estimated off-ART mortality and CD4 progression via an optimisation process that found a best fit to survival curves from cohort studies.

For group 1 countries, we generated age-sex-specific HIV mortality estimates in Spectrum using the incidence and prevalence estimated in EPP. For group 2 countries, we adjusted vital registration data for incompleteness...
and garbage coding (ie, deaths coded to an intermediate, immediate, or poorly defined cause). We further corrected the data for HIV misclassification by identifying causes of death that deviated from expected age patterns of mortality in years with known HIV epidemics, and excess deaths were attributed to HIV. We used spatiotemporal Gaussian process regression to smooth and complete the time series of adjusted vital registration data (appendix 1 p 11). For groups 2A and 2B, we used the smoothed vital registration data to inform Spectrum-estimated mortality through the cohort incidence bias adjustment process. In group 2C countries, we leveraged spatial information by sampling cohort incidence bias adjustment-generated incidence-adjustment scalars in the region, which were then input into Spectrum to create mortality estimates.

The GBD framework produced three distinct sources of HIV mortality estimates: HIV mortality results from Spectrum; estimated excess HIV mortality from the all-cause mortality process; and smoothed HIV-specific mortality from vital registration data. For group 1 countries, we used an ensemble approach to reconcile the differences between HIV mortality estimated by Spectrum and by the all-cause mortality process and generate final HIV mortality. In group 1 countries, EPP and Spectrum estimates were largely driven by HIV prevalence data and mortality estimates generated from cohort data, whereas the all-cause mortality process was primarily based on sibling survival data. For individuals aged 15 years and older, the ensemble model averaged HIV mortality estimates from the two processes with equal weights. For individuals younger than 15 years, we applied the fraction of deaths due to HIV in Spectrum to estimated all-cause mortality to generate HIV-specific mortality and mortality from all other causes (HIV-free mortality). In group 2A countries, we estimated mortality only from vital registration data, and for group 2B and 2C countries we only used Spectrum results.

Forecasting to 2030

We forecasted HIV incidence, prevalence, mortality, and treatment coverage through to 2030 in Spectrum using input parameters extended to 2030. We forecasted the adult ART coverage input on the basis of forecasted ART price, HIV spending on care and treatment, and lag-distributed income (ie, gross domestic product per capita that has been smoothed over the preceding 10 years). We modelled country-year-specific annual ART price per patient using Gaussian process regression with data from the Global Price Reporting Mechanism. We calculated the annualised rate of change of per-capita expenditure on HIV care and treatment in each country since 2010. We then forecast expenditure on HIV care and treatment for each country using the 50th percentile annualised rate of change across countries. We calculated annual dose-equivalents of ART by dividing spending by ART price, and we used logistic regression to model the association between annual dose-equivalents and ART coverage. We forecasted other treatment coverage inputs to Spectrum, such as child ART coverage and prevention of mother-to-child transmission, using the same approach based on the 50th percentile annualised rate of change observed across countries. Forecasting the incidence input had two steps. First, we calculated counterfactual incidence (ie, expected incidence in the absence of ART) using an assumption of 70% viral suppression among those on treatment, then we forecast counterfactual incidence using the 50th percentile annualised rate of change observed across countries in the previous 5 years. Because the forecasted incidence was derived from the counterfactual incidence using forecasted ART coverage, the final forecasted incidence changed in response to both the underlying secular trend and improvements in ART coverage. We used forecasted demographic inputs that were estimated for each location, then we ran Spectrum for all locations. Full details on the methods for forecasting are in appendix 1 (pp 17–22). We used the mean values (rounded to the nearest integer) of the resultant HIV

![Figure 1: Global HIV incidence, prevalence, mortality, and people on ART, by sex, for all ages, 1980–2017](image)

Shaded areas are 95% uncertainty intervals. ART=antiretroviral therapy.
| Region                          | New HIV infections, 2017 | HIV deaths, 2017 | Annualised rate of change in new infections | Annualised rate of change in HIV deaths |
|--------------------------------|--------------------------|------------------|---------------------------------------------|------------------------------------------|
|                                | Females | Males | Total | Females | Males | Total | 1990-2007 | 2007-17 | 1990-2007 | 2007-17 |
| **Global**                     | 966 000 | (786 000 to 1 120 000) | 976 000 | (835 000 to 1 110 000) | 1 940 000 | (1 630 000 to 2 290 000) | 446 000 | (417 000 to 479 000) | 508 000 | (483 000 to 540 000) | 954 000 | (907 000 to 1 010 000) | -0.4% | (-1.2 to -0.3) | -3.0% | (-4.5 to -1.5) | 8.5% | (7.8 to 9.4) | -8.3% | (-8.7 to -7.9) |
| **Low SDI**                    | 259 000 | (176 000 to 378 000) | 177 000 | (124 000 to 257 000) | 436 000 | (303 000 to 627 000) | 132 000 | (120 000 to 147 000) | 131 000 | (121 000 to 143 000) | 262 000 | (244 000 to 288 000) | -5.2% | (-6.2 to -4.2) | -9.5% | (-10.4 to -2.0) | 4.6% | (3.6 to 5.7) | -12.4% | (-13.0 to -11.8) |
| **Low-middle SDI**             | 359 000 | (271 000 to 459 000) | 278 000 | (212 000 to 356 000) | 636 000 | (487 000 to 808 000) | 192 000 | (170 000 to 217 000) | 184 000 | (163 000 to 207 000) | 375 000 | (338 000 to 416 000) | -1.6% | (-2.6 to -0.5) | -4.1% | (-6.1 to -2.0) | 11.3% | (10.0 to 12.4) | -8.5% | (-9.1 to -7.8) |
| **Middle SDI**                 | 240 000 | (196 000 to 287 000) | 280 000 | (245 000 to 317 000) | 521 000 | (450 000 to 591 000) | 105 000 | (94 500 to 119 000) | 153 000 | (143 000 to 165 000) | 238 000 | (241 000 to 278 000) | 6.0% | (4.0 to 8.2) | -3.7% | (-5.3 to -2.1) | 18.6% | (17.9 to 19.3) | -7.8% | (-8.5 to -7.2) |
| **High-middle SDI**            | 80 800 | (69 100 to 94 400) | 167 000 | (139 000 to 198 000) | 247 000 | (210 000 to 297 000) | 14 200 | (13 700 to 15 700) | 31 500 | (30 800 to 34 000) | 45 700 | (44 500 to 47 000) | 3.7% | (3.2 to 4.3) | 7.5% | (5.9 to 9.2) | 4.6% | (4.5 to 4.8) | 0.7% | (0.5 to 1.1) |
| **High SDI**                   | 26 700 | (20 300 to 39 200) | 73 100 | (42 900 to 107 000) | 99 800 | (58 300 to 120 000) | 317 00 | (314 000 to 320 000) | 870 000 | (861 000 to 880 000) | 11 900 | (11 800 to 12 000) | -2.5% | (-3.9 to -1.0) | -1.9% | (-0.8 to 3.2) | -5.7% | (-5.8 to -5.7) | -5.3% | (-5.4 to -5.2) |
| **Central Europe**             | 59 300 | (49 400 to 74 000) | 121 000 | (94 800 to 149 000) | 180 000 | (146 000 to 222 000) | 826 000 | (810 000 to 835 000) | 18 700 000 | (18 400 000 to 18 900 000) | 26 900 000 | (26 700 000 to 27 100 000) | 8.1% | (7.0 to 9.2) | 11.7% | (9.1 to 13.5) | 7.7% | (7.6 to 7.8) | 1.8% | (1.7 to 2.0) |
| **Europe and central Asia**    | 1 000 000 | (869 000 to 1 139 000) | 1 400 000 | (1 239 000 to 1 569 000) | 2 400 000 | (2 040 000 to 2 760 000) | 1 000 000 | (899 000 to 1 101 000) | 1 400 000 | (1 294 000 to 1 506 000) | 2 400 000 | (2 294 000 to 2 556 000) | 0.3% | (0.6 to 0.9) | 0.4% | (0.2 to 0.6) | 0.3% | (0.2 to 0.4) | -0.1% | (-0.2 to 0.1) |

Additional data for individual countries is available in the supplementary material.
| Country          | New HIV infections, 2017 | HIV deaths, 2017 | Annualised rate of change in new infections | Annualised rate of change in HIV deaths |
|------------------|--------------------------|------------------|--------------------------------------------|------------------------------------------|
| Montenegro       | 1.9, (4.4 to 2.0)        | 0.6, (1.0 to 0.4) | (1.1 to 1.7)                               | (1.0 to 1.1)                             |
| Poland           | 151, (532 to 468)        | 144, (32.0 to 112) | (2.8 to 7.6)                               | (2.5 to 7.1)                             |
| Romania          | 258, (437 to 780)        | 165, (47.9 to 118) | (7.6 to 12.6)                              | (7.1 to 11.6)                            |
| Serbia           | 18.5, (112 to 30.9)      | 72.5, (12.3 to 60.2) | (8.3 to 4.5)                               | (7.7 to 4.2)                             |
| Slovakia         | 6.5, (11 to 25.2)        | 21.5, (0.4 to 2.1)  | (7.1 to 15.0)                              | (1.3 to 4.7)                             |
| Latvia           | 16, (9.9 to 21)          | 9.4, (0.3 to 0.4)  | (7.1 to 11.5)                              | (1.1 to 2.2)                             |
| Estonia          | 41.1, (94 to 156)        | 36, (4.3 to 3.7)   | (7.7 to 10.2)                              | (1.1 to 1.8)                             |
| Lithuania        | 115, (59,000 to 210,000) | 73, (77.2 to 140,000) | (8.8 to 3.2)                               | (2.1 to 4.2)                             |
| Moldova          | 377, (248,000 to 320,000) | 124, (45.9 to 124)  | (8.5 to 3.2)                               | (1.8 to 3.1)                             |
| Russia           | 417, (9700 to 130,000)   | 120, (392 to 36,000) | (11.6 to 122)                              | (16.4 to 182)                            |
| Ukraine          | 1180, (7920 to 15600)    | 1800, (2790 to 3450) | (19.9 to 146)                              | (10.9 to 15.0)                           |
| High-income Asia Pacific | 266, (2310 to 2970) | 352, (79 to 312) | (7.9 to 312)                               | (5.0 to 4.2)                             |
| Brunei           | 7, (7.5 to 15)           | 47, (1.4 to 3.7)   | (5.3 to 3.7)                               | (0.7 to 4.7)                             |
| Japan            | 43, (450 to 1460)        | 167, (59 to 147)   | (4.4 to 1.9)                               | (2.1 to 4.5)                             |
| Singapore        | 56, (113 to 1301)        | 36, (31 to 29.6)   | (5.6 to 1.1)                               | (0.9 to 3.0)                             |
| South Africa     | 180, (1310 to 1740)     | 148, (16.1 to 131) | (5.8 to 1.8)                               | (2.9 to 0.8)                             |
| High-income North America | 15600, (39,200 to 58,400) | 7620, (54,000 to 57,400) | (5.6 to 7.6)                               | (7.1 to 8.1)                             |
| Canada           | 942, (2590 to 3530)      | 274, (72.2 to 202) | (1.8 to 3.2)                               | (1.7 to 3.7)                             |
| Greenland        | 62, (47 to 10.9)         | 16, (0.8 to 0.9)   | (1.6 to 1.0)                               | (0.8 to 1.0)                             |

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New HIV infections, 2017

| Country    | Females | Males | Total |
|------------|---------|-------|-------|
| USA        | 14,700  | 36,600| 51,300|
|            | (54,440 to 26,600) | (14,300 to 58,900) | (51,300 to 81,300) |
| Southern Latin America | 6620 | 10,500 | 17,100 |
|            | (30,200 to 12,300) | (38,320 to 17,100) | (57,670 to 69,600) |
| Argentina  | 5750    | 6430  | 12,200 |
|            | (2490 to 10,900) | (3330 to 10,900) | (6000 to 21,000) |
| Chile      | 682     | 3,440 | 4,120 |
|            | (339 to 11,800) | (1850 to 5,490) | (2,220 to 6,690) |

HIV deaths, 2017

| Country    | Females | Males | Total |
|------------|---------|-------|-------|
| Spain      | 1150    | 5380  | 6530  |
|            | (464 to 2,120) | (260 to 9,960) | (2,820 to 11,800) |

Annualised rate of change in new infections

| Country    | 1990-2007 | 2007-17 |
|------------|-----------|---------|
| Africa     | -2.3%     | 1.5%    |
| Asia       | -6.2%     | -6.0%   |
| Europe     | -3.9%     | 1.5%    |
| Southern Latin America | 1.7% | 1.8%    |
| Argentina  | 1.0%      | 1.0%    |
| Chile      | 1.0%      | 0.7%    |

Annualised rate of change in HIV deaths

| Country    | 1990-2007 | 2007-17 |
|------------|-----------|---------|
| Africa     | -6.2%     | -6.0%   |
| Asia       | -6.2%     | -5.9%   |
| Europe     | -6.2%     | -5.9%   |

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### New HIV infections, 2017

| Country          | Females | Males | Total |
|------------------|---------|-------|-------|
| **Andean Latin America** |         |       |       |
| Argentina        | 3,950   | 8,440 | 12,400|
| Bolivia          | 905     | 1,590 | 2,490 |
| Ecuador          | 1,050   | 2,060 | 3,100 |
| Peru             | 1,900   | 4,790 | 6,680 |
| **Caribbean**    | 8830    | 9,990 | 18,830|
| Antigua and Barbuda | 2,6     | 6,3   | 8,9   |
| The Bahamas      | 127     | 227   | 354   |
| Barbados         | 261     | 432   | 693   |
| Belize           | 113     | 222   | 335   |
| Bermuda          | 1,4     | 4,4   | 5,8   |
| Cuba             | 684     | 2,130 | 2,814 |
| Dominican Republic | 1,740  | 2,220 | 3,960 |
| **Grenada**      | 1,9     | 4,6   | 6,5   |
| **Guyana**       | 335     | 626   | 961   |
| **Haiti**        | 450     | 520   | 970   |
| **Jamaica**      | 520     | 751   | 1,271 |
| **Puerto Rico**  | 537     | 1,444 | 1,981 |
| **Saint Lucia**  | 3,4     | 5,4   | 8,8   |
| **Saint Vincent and the Grenadines** | 72       | 137   | 209   |
| **Suriname**     | 938     | 1,14  | 2,07  |

### HIV deaths, 2017

| Country          | Females | Males | Total |
|------------------|---------|-------|-------|
| **Andean Latin America** |         |       |       |
| Argentina        | 160     | 306   | 466   |
| Bolivia          | 458     | 709   | 1,170 |
| Ecuador          | 271     | 822   | 1,093 |
| Peru             | 868     | 1,530 | 2,408 |
| **Caribbean**    | 3,460   | 5,100 | 8,560 |
| Antigua and Barbuda | 2.3    | 5.2   | 7.5   |
| The Bahamas      | 47.2    | 67.0  | 114   |
| Barbados         | 8.8     | 16.2  | 25.0  |
| Belize           | 16.6    | 33.9  | 50.5  |
| Bermuda          | 8.3     | 10.7  | 19.0  |
| Cuba             | 56.8    | 301   | 357   |
| Dominican Republic | 853    | 3710  | 4,563 |
| **Grenada**      | 1.7     | 4.5   | 6.2   |
| **Guyana**       | 79.4    | 116   | 195   |
| **Haiti**        | 1860    | 2,190 | 4,050 |
| **Jamaica**      | 187     | 253   | 440   |
| **Puerto Rico**  | 68.6    | 171   | 239   |
| **Saint Lucia**  | 1.2     | 3.2   | 4.5   |
| **Saint Vincent and the Grenadines** | 2.0    | 4.8   | 6.8   |
| **Suriname**     | 40.2    | 61.6  | 101.8 |

### Annualised rate of change in new infections

| Country          | 1990-2007 | 2007-17 | 1990-2007 | 2007-17 |
|------------------|-----------|---------|-----------|---------|
| **Andean Latin America** | -5.1%    | 1.5%    | -4.6%     | 3.3%    |
| **Caribbean**    | -4.7%     | 0.2%    | -3.9%     | 2.9%    |
| **Grenada**      | -6.2%     | 0.1%    | -7.6%     | 0.8%    |
| **Guyana**       | 5.0%      | -1.6%   | 7.6%      | -3.4%   |
| **Haiti**        | -8.5%     | -0.8%   | -10.1%    | -0.6%   |
| **Jamaica**      | -0.5%     | 1.2%    | -2.2%     | 3.3%    |
| **Puerto Rico**  | -14.6%    | 2.8%    | -16.0%    | 5.7%    |
| **Saint Lucia**  | -6.8%     | 1.6%    | -8.1%     | -2.2%   |
| **Saint Vincent and the Grenadines** | -6.2% | 1.2% | -2.7% | -2.3% |
| **Suriname**     | -0.7%     | 0.2%    | -4.6%     | 1.9%    |

(Continued from previous page)
| Country/Region | New HIV infections, 2017 | HIV deaths, 2017 | Annualised rate of change in new infections | Annualised rate of change in HIV deaths |
|---------------|--------------------------|----------------|-------------------------------------------|------------------------------------------|
|               | Females | Males | Total | Females | Males | Total | 1990–2007 | 2007–17 | 1990–2007 | 2007–17 |
| Trinidad and Tobago | 187 | 227 | 414 | 83 | 136 | 219 | -1.0% | -1.1% | 4.3% | -2.3% |
| Virgin Islands | 3 | 10.7 | 14.7 | 3 | 6.0 | 9.0 | 4.1% | 4.4% | 0.3% | -0.6% |
| Central America | 1050 | 35 | 300 | 45 | 800 | 330 | -0.9% | -2.4% | 4.6% | -1.8% |
| Mexico | 3930 | 5000 | 8300 | 66 | 190 | 2640 | 2.9% | 5.0% | 8.4% | -2.3% |
| Costa Rica | 914 | 295 | 1209 | 385 | 115 | 500 | 0.9% | -3.5% | 2.2% | -0.4% |
| El Salvador | 458 | 789 | 1247 | 447 | 481 | 728 | 7.1% | -9.4% | 11.5% | -1.0% |
| Guatemala | 830 | 1480 | 2310 | 86 | 237 | 700 | 2.7% | -8.6% | 3.2% | -5.4% |
| Honduras | 211 | 268 | 479 | 25 | 37 | 62 | 0.5% | -3.0% | -0.9% | -8.2% |
| Mexico | 3930 | 15900 | 19800 | 1250 | 4330 | 5580 | -3.8% | 2.8% | 3.7% | -2.4% |
| Nicaragua | 218 | 1240 | 1466 | 195 | 295 | 490 | 14.3% | 6.1% | 11.3% | 9.5% |
| Panama | 426 | 1480 | 1907 | 128 | 375 | 562 | -1.0% | 4.8% | 3.4% | -1.0% |
| Venezuela | 1370 | 6830 | 8200 | 557 | 1500 | 2130 | 3.9% | 2.8% | 3.1% | -0.1% |
| Tropical Latin America | 29000 | 56000 | 85000 | 5720 | 10500 | 16200 | 2.7% | 3.4% | 1.7% | -0.9% |
| Brazil | 2840 | 55000 | 83300 | 5430 | 9970 | 15400 | 2.6% | 3.5% | 1.6% | -1.2% |
| Paraguay | 638 | 1000 | 1640 | 283 | 478 | 762 | 11.8% | -0.1% | 11.9% | 5.4% |
| North Africa and Middle East | 8300 | 59400 | 175000 | 4690 | 4750 | 9440 | 4.2% | -0.4% | 10.5% | 0.5% |
| Afghanistan | 353 | 569 | 922 | 108 | 194 | 302 | 2.0% | -8.6% | 8.4% | 4.3% |
| Algeria | 396 | 500 | 901 | 130 | 197 | 327 | 8.7% | -3.5% | 8.9% | -2.2% |
| Bahrain | 4.6 | 155 | 202 | 3.0 | 8.5 | 11.5 | -4.3% | -1.6% | -1.8% | -6.4% |
| Egypt | 154 | 403 | 557 | 22.5 | 42.3 | 64.8 | 0.6% | 6.8% | 1.3% | -7.2% |
| Iran | 1540 | 1610 | 3150 | 322 | 470 | 792 | 8.7% | 10.3% | 10.2% | 5.3% |
| Iraq | 124 | 104 | 228 | 60.6 | 55.1 | 116 | 4.9% | 5.0% | 9.3% | 2.7% |
| Jordan | 18.5 | 51.2 | 69.7 | 8.5 | 12.6 | 21.1 | 2.9% | 2.6% | 6.9% | 2.6% |
| Kuwait | 4.8 | 10.6 | 15.4 | 2.9 | 2.5 | 5.4 | 3.1% | 1.4% | 2.2% | -5.1% |
| Lebanon | 92.2 | 162 | 254 | 48.6 | 63.9 | 113 | -2.4% | 3.7% | -0.6% | -1.2% |

(Table continues on next page)
### New HIV Infections, 2017

| Country         | Females | Males | Total |
|-----------------|---------|-------|-------|
| Libya           | 95.0    | 93.9  | 188.9 |
| Morocco         | 557.0   | 551.1 | 1108.1|
| Oman            | 54.4    | 595   | 649.4|
| Palestine       | 9.2     | 10.8  | 20.0  |
| Qatar           | 2.4     | 8.1   | 10.5  |
| Saudi Arabia    | 33.1    | 342   | 375.1 |
| Sudan           | 376.0   | 2810  | 3196.0|
| Syria           | 11.0    | 30.8  | 41.8  |
| Tunisia         | 180.0   | 251   | 431   |
| Turkey          | 17.1    | 303   | 474   |
| United Arab Emirates | 42.0  | 195  | 615   |
| Yemen           | 393.0   | 689   | 1082  |
| **South Asia**  | 499.0   | 6770  | 7269  |
| Bangladesh      | 414.0   | 542   | 956   |
| Bhutan          | 41.0    | 94.2  | 135   |
| India           | 436.0   | 5500  | 5936  |
| Nepal           | 84.2    | 1420  | 2264  |
| Pakistan        | 499.0   | 9930  | 14920 |
| **Southeast Asia, Asia, and Oceania** | 39200 | 49200 | 88400 |

### HIV Deaths, 2017

| Country         | Females | Males | Total |
|-----------------|---------|-------|-------|
| Libya           | 47.3    | 56.0  | 103   |
| Morocco         | 246.0   | 356   | 602   |
| Oman            | 11.4    | 122   | 133.4 |
| Palestine       | 4.6     | 5.7   | 10.3  |
| Qatar           | 2.2     | 4.7   | 7.0   |
| Saudi Arabia    | 245.0   | 281   | 526   |
| Sudan           | 31.0    | 2190  | 2500  |
| Syria           | 6.6     | 4.7   | 11.3  |
| Tunisia         | 80.4    | 113   | 194   |
| Turkey          | 70.6    | 130   | 260   |
| United Arab Emirates | 23.5  | 181  | 412   |
| Yemen           | 135.0   | 252   | 387   |
| **South Asia**  | 260.0   | 35100 | 37700 |
| Bangladesh      | 266.0   | 361   | 627   |
| Bhutan          | 241.0   | 572   | 813   |
| India           | 234.0   | 28700 | 31040 |
| Nepal           | 762.0   | 1860  | 2620  |
| Pakistan        | 178.0   | 3530  | 5310  |
| **Southeast Asia, Asia, and Oceania** | 26600 | 35100 | 61700 |

### Annualised Rate of Change in New Infections, 1990–2007 & 2007–17

| Region          | 1990–2007 | 2007–17 |
|-----------------|-----------|---------|
| Asia, east Asia | 5.4%      | 5.2%    |
| Africa          | 5.8%      | 4.0%    |
| Middle East     | 4.2%      | 2.3%    |
| Latin America   | 5.8%      | 4.0%    |
| Central Asia    | 9.8%      | 4.9%    |
| South Asia      | 4.2%      | 2.3%    |
| Southeast Asia  | 5.8%      | 4.0%    |

### Annualised Rate of Change in HIV Deaths, 1990–2007 & 2007–17

| Region          | 1990–2007 | 2007–17 |
|-----------------|-----------|---------|
| Asia, east Asia | 5.4%      | 5.2%    |
| Africa          | 5.8%      | 4.0%    |
| Middle East     | 4.2%      | 2.3%    |
| Latin America   | 5.8%      | 4.0%    |
| Central Asia    | 9.8%      | 4.9%    |
| South Asia      | 4.2%      | 2.3%    |
| Southeast Asia  | 5.8%      | 4.0%    |

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| Articles | www.thelancet.com/hiv | Published online August 19, 2019 | http://dx.doi.org/10.1016/S2352-3018(19)30196-1 | 11 |
| --- | --- | --- | --- | --- |

### New HIV infections, 2017

| Region | Females | Males | Total |
| --- | --- | --- | --- |
| American Samoa | 0.2 | 0.5 | 0.7 |
| Federated States of Micronesia | 34.5 | 39.6 | 74.1 |
| Fiji | 24.8 | 22.1 | 46.9 |
| Guam | 0.8 | 6.7 | 7.5 |
| Kiribati | 0.3 | 0.4 | 0.7 |
| Marshall Islands | 3.9 | 3.8 | 7.7 |
| Northern Mariana Islands | 0.2 | 0.6 | 0.7 |
| Papua New Guinea | 1730 | 1320 | 3050 |
| Samoa | 13.2 | 13.2 | 26.4 |
| Solomon Islands | 42.8 | 37.0 | 79.8 |
| Tonga | 1.1 | 1.5 | 2.6 |
| Vanuatu | 20.7 | 17.7 | 38.3 |
| Southeast Asia | 29800 | 67200 | 97500 |
| Cambodia | 561 | 485 | 1050 |
| Indonesia | 6480 | 11300 | 17700 |
| Laos | 223 | 579 | 802 |
| Malaysia | 1200 | 3180 | 4370 |
| Maldives | 0.9 | 0.3 | 1.2 |
| Mauritius | 104 | 194 | 298 |
| Myanmar | 4970 | 4740 | 9710 |
| Philippines | 3170 | 11100 | 14300 |
| Sri Lanka | 101 | 190 | 291 |
| Seychelles | 4 | 34 | 58 |
| Thailand | 9550 | 15000 | 24500 |
| Timor-Leste | 97.3 | 153 | 250 |

### HIV deaths, 2017

| Region | Females | Males | Total |
| --- | --- | --- | --- |
| American Samoa | 0.1 | 0.2 | 0.3 |
| Federated States of Micronesia | 34.5 | 39.6 | 74.1 |
| Fiji | 24.8 | 22.1 | 46.9 |
| Guam | 0.8 | 6.7 | 7.5 |
| Kiribati | 0.3 | 0.4 | 0.7 |
| Marshall Islands | 3.9 | 3.8 | 7.7 |
| Northern Mariana Islands | 0.2 | 0.6 | 0.7 |
| Papua New Guinea | 1730 | 1320 | 3050 |
| Samoa | 13.2 | 13.2 | 26.4 |
| Solomon Islands | 42.8 | 37.0 | 79.8 |
| Tonga | 1.1 | 1.5 | 2.6 |
| Vanuatu | 20.7 | 17.7 | 38.3 |
| Southeast Asia | 29800 | 67200 | 97500 |
| Cambodia | 561 | 485 | 1050 |
| Indonesia | 6480 | 11300 | 17700 |
| Laos | 223 | 579 | 802 |
| Malaysia | 1200 | 3180 | 4370 |
| Maldives | 0.9 | 0.3 | 1.2 |
| Mauritius | 104 | 194 | 298 |
| Myanmar | 4970 | 4740 | 9710 |
| Philippines | 3170 | 11100 | 14300 |
| Sri Lanka | 101 | 190 | 291 |
| Seychelles | 4 | 34 | 58 |
| Thailand | 9550 | 15000 | 24500 |
| Timor-Leste | 97.3 | 153 | 250 |

### Annualised rate of change in new infections

| Region | 1990-2007 | 2007-17 |
| --- | --- | --- |
| American Samoa | -1.8% | 3.2% |
| Federated States of Micronesia | 10.2% | 7.3% |
| Fiji | 25.4% | 4.3% |
| Guam | -3.6% | 4.0% |
| Kiribati | -6.6% | 9.0% |
| Marshall Islands | 0.1% | 7.9% |
| Northern Mariana Islands | -0.6% | 3.9% |
| Papua New Guinea | 25.2% | -5.9% |
| Samoa | 0.7% | 8.1% |
| Solomon Islands | -0.1% | 7.5% |
| Tonga | -0.2% | 4.0% |
| Vanuatu | -2.3% | 2.4% |
| Southeast Asia | -1.5% | -2.2% |
| Cambodia | 2.3% | -10.4% |
| Indonesia | 3.2% | 3.2% |
| Laos | 5.8% | 3.2% |
| Malaysia | -0.7% | 0.2% |
| Maldives | -3.2% | 19.4% |
| Mauritius | -0.2% | -2.1% |
| Myanmar | 0.2% | 3.7% |
| Philippines | -0.5% | 0.1% |
| Sri Lanka | -0.6% | 7.8% |
| Seychelles | -5.1% | -2.4% |
| Thailand | -5.3% | -3.6% |
| Timor-Leste | -0.6% | 4.2% |

### Annualised rate of change in HIV deaths

| Region | 1990-2007 | 2007-17 |
| --- | --- | --- |
| American Samoa | -1.8% | 3.2% |
| Federated States of Micronesia | 10.2% | 7.3% |
| Fiji | 25.4% | 4.3% |
| Guam | -3.6% | 4.0% |
| Kiribati | -6.6% | 9.0% |
| Marshall Islands | 0.1% | 7.9% |
| Northern Mariana Islands | -0.6% | 3.9% |
| Papua New Guinea | 25.2% | -5.9% |
| Samoa | 0.7% | 8.1% |
| Solomon Islands | -0.1% | 7.5% |
| Tonga | -0.2% | 4.0% |
| Vanuatu | -2.3% | 2.4% |
| Southeast Asia | -1.5% | -2.2% |
| Cambodia | 2.3% | -10.4% |
| Indonesia | 3.2% | 3.2% |
| Laos | 5.8% | 3.2% |
| Malaysia | -0.7% | 0.2% |
| Maldives | -3.2% | 19.4% |
| Mauritius | -0.2% | -2.1% |
| Myanmar | 0.2% | 3.7% |
| Philippines | -0.5% | 0.1% |
| Sri Lanka | -0.6% | 7.8% |
| Seychelles | -5.1% | -2.4% |
| Thailand | -5.3% | -3.6% |
| Timor-Leste | -0.6% | 4.2% |

(Continued from previous page)
| Country/Region | New HIV infections, 2017 | HIV deaths, 2017 | Annualised rate of change in new infections | Annualised rate of change in HIV deaths |
|---------------|-------------------------|-----------------|---------------------------------|---------------------------------|
|                | Total | Females | Males | Total | Females | Males | Total | 1990–2007 | 2007–17 |
| Vietnam        | 3360  | 15,700  | 19,100 | 933   | 10,500  | 11,400 | $8\%$ | (3.9 to 8.1) | -2.3\% | (3.8 to 0.5) | 16.7\% | (14.6 to 18.5) | -1.3\% | (3.0 to 1.1) |
| Sub-Saharan Africa | 723,000 | 487,000 | 235,000 | 362,000 | 349,000 | 712,000 | $2.8\%$ | (-3.8 to -1.9) | -5.9\% | (13.6 to -3.6) | 7.8\% | (7.0 to 8.7) | -11.1\% | (11.5 to -10.6) |
| Central Africa | 32,100 | 17,200  | 16,900 | 28,700 | 16,600  | 44,300 | $-2.9\%$ | (-4.6 to -1.3) | -7.1\% | (2.1 to 4.7) | 3.4\% | (-10.2 to -7.8) | -9.1\% |
| sub-Saharan Africa | 52,300 | 27,500  | 24,800 | 49,600 | 48,400  | 98,000 | $12.4\%$ | (6.2 to 20.4) | -6.3\% | (37.2 to 24.7) | 21.7\% | (0.3 to -0.6) | -1.0\% | (1.7 to -1.7) |
| Angola | 12,600 | 6,380  | 6,220 | 12,700 | 4,840  | 17,500 | $12.4\%$ | (6.2 to 20.4) | -6.3\% | (37.2 to 24.7) | 21.7\% | (0.3 to -0.6) | -1.0\% | (1.7 to -1.7) |
| Central African Republic | 3,470 | 1,520  | 1,950 | 3,500 | 2,270  | 5,720 | $-7.8\%$ | (-11.0 to -5.5) | -3.1\% | (3.4 to 7.9) | 5.4\% | (-10.4 to -9.4) |
| Congo (Brazzaville) | 4,390 | 2,570  | 1,820 | 4,310 | 2,180  | 6,490 | $-4.5\%$ | (-6.6 to -1.7) | -2.0\% | (1.1 to 2.9) | 0.9\% | (-5.7 to -3.4) |
| Democratic Republic of the Congo | 35,900 | 18,100  | 17,800 | 35,100 | 18,000  | 53,100 | $-4.5\%$ | (-6.6 to -1.7) | -2.0\% | (1.1 to 2.9) | 0.9\% | (-5.7 to -3.4) |
| Equatorial Guinea | 1,510 | 853  | 657 | 1,090 | 665  | 1,750 | $8.2\%$ | (2.5 to 15.5) | -8.3\% | (11.9 to 21.1) | 17.5\% | (-0.8 to 19.0) |
| Gabon | 497 | 228  | 275 | 410 | 234  | 644 | $0.3\%$ | (-0.4 to 3.7) | -12.8\% | (4.9 to 13.5) | 11.4\% | (-17.2 to -11.6) |
| Eastern Africa | 259,000 | 175,000  | 84,000 | 212,000 | 122,000  | 244,000 | $-5.8\%$ | (-9.3 to -2.5) | -6.2\% | (4.1 to 6.3) | 5.1\% | (-13.9 to 1.3) |
| sub-Saharan Africa | 351,000 | 243,000  | 108,000 | 231,000 | 122,000  | 353,000 | $-5.8\%$ | (-9.3 to -2.5) | -6.2\% | (4.1 to 6.3) | 5.1\% | (-13.9 to 1.3) |
| Burundi | 1,880 | 1,160  | 720 | 1,150 | 1,450  | 2,600 | $-17.8\%$ | (-24.1 to -10.7) | -11.6\% | (5.8 to 14.1) | 10.5\% | (-19.9 to 16.6) |
| Comoros | 33 | 10  | 23 | 33 | 13  | 46 | $10.4\%$ | (0.7 to 23.5) | 15.2\% | (2.6 to 41.0) | 2.7\% | (-17.5 to 12.5) |
| Djibouti | 474 | 345  | 129 | 415 | 308  | 724 | $14.9\%$ | (3.8 to 26.9) | -1.5\% | (32.6 to 59.3) | 44.0\% | (-8.7 to 4.3) |
| Eritrea | 1,070 | 955  | 115 | 1,060 | 955  | 2,015 | $-8.5\%$ | (1.0 to 16.3) | -1.4\% | (21.5 to 6.1) | 7.4\% | (-19.7 to -18.4) |
| Ethiopia | 9,080 | 5,400  | 3,680 | 9,180 | 8,000  | 17,200 | $-18.9%$ | (12.7 to 5.0) | -1.4\% | (32.6 to 59.3) | 44.0\% | (-8.7 to 4.3) |
| Kenya | 55,900 | 36,900  | 19,000 | 56,900 | 36,900  | 93,800 | $-6.1\%$ | (-7.5 to -4.8) | -3.5\% | (9.0 to 11.1) | 10.1\% | (-11.0 to -17.1) |
| Madagascar | 57,500 | 35,700  | 21,800 | 58,000 | 35,700  | 93,700 | $18.4\%$ | (8.0 to 31.5) | 9.8\% | (36.8 to 64.4) | 46.0\% | (-6.6 to -5.5) |
| Malawi | 16,100 | 12,000  | 4,100 | 16,100 | 12,000  | 28,100 | $-7.0\%$ | (8.5 to -5.5) | -10.8\% | (6.0 to 11.4) | 8.5\% | (-17.2 to -18.5) |
| Mozambique | 79,100 | 54,000  | 25,100 | 79,600 | 54,000  | 133,600 | $5.4\%$ | (3.5 to 7.5) | -5.2\% | (16.0 to 21.6) | 8.4\% | (-9.0 to -6.7) |
| Rwanda | 3,390 | 2,390  | 1,000 | 3,260 | 2,300  | 5,560 | $6.1\%$ | (-5.3 to -2.1) | -7.2\% | (16.0 to 21.6) | 10.2\% | (-17.0 to -15.3) |
| Somalia | 1320 | 1060  | 260 | 1,280 | 1,110  | 2,390 | $-1.4\%$ | (-10.6 to 7.8) | -5.8\% | (8.7 to 21.7) | 15.6\% | (-7.0 to -4.6) |

(Table continues on next page)
| Articles |
| --- |

### New HIV infections, 2017

| Southern Africa | Sub-Saharan Western Africa |
| --- | --- |
| **Ghana** | **The Gambia** |
| 150 | 130 |
| **Zimbabwe** | **Namibia** |
| 200 | 170 |
| **South Africa** | **Zimbabwe** |
| 200 | 170 |
| **Benin** | **Burkina Faso** |
| 150 | 120 |
| **Cameroon** | **Cape Verde** |
| 100 | 70 |
| **Chad** | **Côte d’Ivoire** |
| 150 | 120 |
| **The Gambia** | **Ghana** |
| 70 | 50 |

### HIV deaths, 2017

| Southern Africa | Sub-Saharan Western Africa |
| --- | --- |
| **Ghana** | **The Gambia** |
| 150 | 130 |
| **Zimbabwe** | **Namibia** |
| 200 | 170 |
| **South Africa** | **Zimbabwe** |
| 200 | 170 |
| **Benin** | **Burkina Faso** |
| 150 | 120 |
| **Cameroon** | **Cape Verde** |
| 100 | 70 |
| **Chad** | **Côte d’Ivoire** |
| 150 | 120 |
| **The Gambia** | **Ghana** |
| 70 | 50 |

### Annualised rate of change in new infections

| Southern Africa | Sub-Saharan Western Africa |
| --- | --- |
| **Ghana** | **The Gambia** |
| 150 | 130 |
| **Zimbabwe** | **Namibia** |
| 200 | 170 |
| **South Africa** | **Zimbabwe** |
| 200 | 170 |
| **Benin** | **Burkina Faso** |
| 150 | 120 |
| **Cameroon** | **Cape Verde** |
| 100 | 70 |
| **Chad** | **Côte d’Ivoire** |
| 150 | 120 |
| **The Gambia** | **Ghana** |
| 70 | 50 |

### Annualised rate of change in HIV deaths

| Southern Africa | Sub-Saharan Western Africa |
| --- | --- |
| **Ghana** | **The Gambia** |
| 150 | 130 |
| **Zimbabwe** | **Namibia** |
| 200 | 170 |
| **South Africa** | **Zimbabwe** |
| 200 | 170 |
| **Benin** | **Burkina Faso** |
| 150 | 120 |
| **Cameroon** | **Cape Verde** |
| 100 | 70 |
| **Chad** | **Côte d’Ivoire** |
| 150 | 120 |
| **The Gambia** | **Ghana** |
| 70 | 50 |

(Continued from previous page)
forecasts to determine whether countries were on track to meet the 2020 and 2030 UNAIDS targets.

**Uncertainty analysis**

We propagated uncertainty by generating 1000 draws of key inputs, including draw-level linkage of HIV-free mortality with the GBD all-cause mortality process. We ran EPP and Spectrum 1000 times per location to generate results for each draw. We present results with 95% uncertainty intervals (UIs).

**Role of the funding source**

The funder of the study had no role in study design, data collection, data analysis, data interpretation, or the writing of the report. All authors had full access to the data in the study and had final responsibility for the decision to submit for publication.

**Results**

Global deaths from HIV peaked in 2006 and have since decreased from 1·95 million (95% UI 1·87–2·04) deaths in 2006 to 0·95 million (0·91–1·01) in 2017 (figure I). Global ART coverage increased from 2·98 million (2·44–3·58) in 2006 to 21·8 million (20·7–22·9) in 2017. The number of new HIV infections peaked in 1999 (3·16 million [2·79–3·67]) and has gradually decreased thereafter. Between 2007 and 2017, the global age-standardised annualised rate of change in HIV incidence decreased by 3·0% (1·5–4·5), with the number of new cases decreasing from 2·35 million (2·02–2·76) in 2007 to 1·94 million (1·63–2·29) in 2017 (table, figure I). The confluence of these trends produces a steady increase in the total number of people living with HIV. Prevalence has increased from 8·74 million (7·90–9·68) people living with HIV in 1990 to 36·8 million (34·8–39·2) in 2017.
New infections among women were mostly among younger adults, with 20·8% (19·2–22·4) of new infections occurring among females aged 20–24 years in 2017, relatively unchanged from the incidence in 2007 (20·9%, 19·8–22·1). In 2017, males aged 25–29 years had the highest incidence of all male age groups, accounting for 18·6% (16·1–23·1) of new infections that year, which is a substantial change from 2007, when the highest incidence in males occurred among those younger than 1 year. Although HIV infections in children have decreased substantially with the scale-up interventions for prevention of mother-to-child transmission, in 2017, 139555 (121893–159064) new infections were in children younger than 1 year, and 122254 (112228–132591) HIV deaths were in children younger than 15 years. Most HIV deaths in people younger than 15 years are in children younger than 5 years, but this proportion has decreased from 82·1% (82·0–82·1) in 2007 to 63·4% (60·8–65·8) in 2017, showing the increase in lifespan for children who are HIV positive.

Along with substantial variation in ART coverage (figure 3), sub-Saharan Africa had the highest prevalence of HIV in 2017 (figure 4). Males in three countries (Gabon, eSwatini, and Zimbabwe) and females in five countries (Gabon, Rwanda, Botswana, eSwatini, and Zimbabwe) with HIV prevalences of greater than one per 1000 population reached ART coverage of 81% or higher in 2017, reflecting early attainment of the second 90 of the UNAIDS 90-90-90 targets (figure 3). Countries across southern sub-Saharan Africa achieved higher proportions of treatment coverage than those in other sub-Saharan African regions, ranging from 66% in Lesotho to 86% in eSwatini. The estimated proportion of people living with HIV who were on treatment was higher among women than men in all but eight countries in sub-Saharan Africa (Angola, Benin, Cape Verde, Democratic Republic of the Congo, Djibouti, Eritrea, Madagascar, and São Tomé and Príncipe), Additional results detailing proportions of males and females on and off ART by GBD super-region are in appendix 2 (pp 25–31). Overall ART coverage has increased substantially over the past decade in some countries (figure 5). Between 2007 and 2017, 42 countries had annualised rates of change in ART coverage greater than 25%.

In 2017, South Africa had a higher number of new infections than all other countries, with 0·28 million (95% UI 0·21 to 0·35) new cases (table). The incidence for both sexes was highest in Lesotho in 2017, where the age-standardised rate of new cases was 6·2 (4·5 to 8·2) per 1000 population (figure 4). From 2007 to 2017, the annualised rate of change in incidence in Lesotho was –7·1% (95% UI –10·7 to –4·4), which is a drastic change from the positive annualised rate of change in incidence from 1990 to 2007 (2·8%, 1·1 to 4·5; table). Substantial progress has been made by most countries in sub-Saharan Africa, and Comoros was the only country that had an increase in incidence from 2007 to 2017, with an annualised rate of change of 12·8% (0·7 to 23·5). By contrast, many countries in eastern Europe and central Asia saw a sharp increase in the number of new infections in the past decade, with the highest annualised rate of change seen in Russia at 13·2% (10·3 to 15·5). Most countries in western Europe and North America also showed stagnant or increasing annualised rates of change in incidence (table).

Between 2007 and 2017, 122 of 195 countries had a decrease in the rate of change in age-standardised HIV mortality. Notably, the countries that achieved the most rapidly decreasing annual rates of change were Ethiopia (−19·7%, 95% UI −20·9 to −18·4), Burundi (−19·9%, −22·1 to −16·8), and Zimbabwe (−20·8%, −22·9 to −17·4; table). Lesotho had the highest age-standardised mortality in 2017, with mortality for both sexes combined being 3·4 (95% UI 3·0 to 4·0) per 1000 population (figure 4). The annualised rate of change in mortality between 2007 and 2017 in Lesotho was −10·9% (−11·9 to −9·2), and prevalence in Lesotho increased from 153·2 (142·7 to 164·7) per 1000 population in 2007 to 177·8 (168·9 to 187·8) per 1000 population in 2017 (data available from GBD datahub).

In our forecasting, we found that progress towards meeting the ART coverage target is more optimistic than progress towards the incidence or mortality targets. Global
ART coverage was forecast to be 64·8% (95% UI 61·1–67·0) in 2020 and 71·9% (68·2–75·0) in 2030 (appendix 2 pp 3–12). A substantial number of countries are predicted to meet ART coverage targets (figure 6), with 54 countries expected to meet the 2020 target of 81% ART coverage (90% started, 90% retained) and 12 expected to meet the 2030 target of 90% ART coverage (95% started, 95% retained). Of the 54 countries forecast to meet the 2020 ART coverage target, 25 are in the high-income super-region; 11 are in central Europe, eastern Europe, and central Asia; ten are in sub-Saharan Africa; six are in Latin America and the Caribbean; and two are in other regions (Mauritius and Kuwait; figure 6; appendix 2 pp 3–12).

Looking ahead, 38 countries had a forecast coverage of at least 85% but less than the 90% target in 2030. Compared with ART coverage, fewer countries are expected to achieve the UNAIDS 2020 or 2030 targets associated with mortality (figure 7; appendix 2 pp 13–18). Six countries (Burundi, Ethiopia, Gabon, eSwatini, Zambia, and Zimbabwe) were forecasted to achieve the 2020 target for mortality percentage reduction and two (Ethiopia and eSwatini) were forecasted to achieve the 2030 target. Although still short of the target, an additional eight countries (Botswana, Democratic Republic of the Congo, India, Cambodia, Myanmar, Togo, Tanzania, and South Africa) were forecasted to have a reduction in mortality of at least 65% between 2010 and 2020, and six (Burundi, Botswana, Gabon, Cambodia, South Africa, Zambia) were forecasted to have a reduction of at least 80% between 2010 and 2030. Forecasted trends in incidence show the least progress, with no countries meeting the UNAIDS 2030 target (figure 7; appendix 2 pp 19–24).

**Discussion**

Globally, great progress has been made in reducing HIV-related incidence and mortality since their peaks earlier in the epidemic, consistent with the positive trend in ART coverage. Despite the scale-up of ART over time, in 2017, 40·5% (95% UI 37·8–43·7) of the 36·82 million
(34·79–39·20) people estimated to be living with HIV globally were still not on treatment. In the same year, 1·94 million (1·63–2·29) people were newly infected with HIV and 0·95 million (0·91–1·01) people died from HIV-related causes. Trends in new infections and mortality are our primary indicators of progress, and over the past decade HIV incidence has been decreasing more slowly than mortality. Thus, decreases will need to be accelerated to achieve global targets. Although 54 countries are on track to meet the 2020 target of 81% ART coverage (90% started, 90% retained), only 12 countries are expected to meet the 2030 target of 90% ART coverage (95% started, 95% retained). Our forecasts show that fewer than ten countries will meet the mortality or incidence targets in 2020 and 2030.

Annualised rates of change in age-standardised HIV incidence and mortality between 2007 and 2017 varied considerably across countries. The substantial decreases in many sub-Saharan African countries underscore the enormous effort by governments and multilateral organisations to improve HIV prevention and provide effective treatment in these countries. For example, in Zimbabwe, high levels of personal exposure to AIDS deaths and prevention campaigns coupled with a relatively well educated population appear to have shifted social norms and catalysed partner reduction, which are thought to have contributed to steep decreases in HIV prevalence. eSwatini saw success after implementation of a multisectoral response with investments that prioritised ART scale-up, voluntary medical male circumcision, and prevention interventions aimed at adolescent women, mother-to-child transmission of HIV, and tuberculosis–HIV co-infection. Scale-up of a combination strategy of ART and medical male circumcision, funded by the President’s Emergency Plan for AIDS Relief (PEPFAR), was found to have population-level impact in Uganda in reducing incidence. Decreases in HIV burden in Botswana have been attributed to nearly complete coverage of interventions for prevention of mother-to-child transmission and expansion of ART, which might also have reduced stigma.

Conversely, between 2007 and 2017 many countries in eastern Europe and central Asia saw increasing rates of new HIV infections and persistently high mortality; Russia reached the highest annual increase in incidence at 13·2% (95% UI 10·3–15·5). The growing epidemic seen in much of eastern Europe and central Asia stems from multiple factors, including limited access to ART, inadequate access to harm-reduction services (eg, needle and syringe programmes, and opioid substitution therapy), and high levels of stigma.
treatment has been shown to lead to substantial reductions in risk of HIV infection among people who inject drugs; however, opioid substitution therapy remains unavailable in Russia.\textsuperscript{19} The particularly steep increases in new infections in Russia could also be linked to poor access to care for high-risk populations and elimination of Global Fund support.\textsuperscript{20}

Our results showed stagnant or increasing annualised rates of change in incidence in many countries in western Europe and North America. In these countries, the HIV epidemic is largely driven by men who have sex with men (MSM).\textsuperscript{21} Challenges in the scale-up of HIV prevention programmes for MSM have been reported, including limited access to HIV testing and care and financial barriers.\textsuperscript{22} For example, the US Centers for Disease Control and Prevention estimated that MSM accounted for 66% of all HIV diagnoses in 2017 in the USA, and studies have shown high proportions of MSM are unaware of their status.\textsuperscript{23,24} Increasing testing among high-risk populations is paramount to HIV prevention, because those who are aware of their status can decrease the risk of future transmission.\textsuperscript{24,25} Additionally, increases in injection drug use in the USA have been linked with HIV outbreaks, and treatment efforts could be improved because fewer than 10% of those dependent on opioids are receiving substitution therapy.\textsuperscript{26}

We found higher proportions of new infections among younger women (aged 20–24 years) than in men of the same age group in 2017. Higher risk of HIV infection among young women than in young men has been...
linked to several factors, including social factors such as poverty and low education, cultural factors such as transactional sex, laws that deter young women from accessing sexual and reproductive health services, and exposure to intimate partner violence.\textsuperscript{27,28} Ambitious interventions that address multiple causes of young women’s vulnerability to HIV infection in sub-Saharan African countries are underway.\textsuperscript{29}

Few countries are on track to meet the global targets for incidence. Achieving reductions in incidence is complex because it requires increased coverage for both prevention and treatment interventions. A large body of literature has explored various intervention options.\textsuperscript{30} The HIV prevention cascade has been proposed as a novel framework to guide and monitor the design of interventions to maximise coverage at the population level. Krishnaratne and colleagues\textsuperscript{30} found that direct interventions, including overall pre-exposure prophylaxis medications and medical male circumcision, were efficacious for reducing incidence. Additionally, the consensus statement issued in 2016, and endorsed by over 760 organisations to date, states that undetectable viral load is equivalent to non-transmittable infection based on strong scientific evidence that HIV cannot be transmitted sexually by those with an undetectable viral load.\textsuperscript{31} This evidence suggests that increasing access to early treatment and interventions to improve adherence can support further decreases in incidence. Still, few countries are forecast to achieve the 2030 ART coverage target of 95% covered and 95% retained.

Although treatment access and prevention mechanisms exist and can be widely implemented, inadequate ART coverage and adherence could perpetuate the AIDS epidemic. Achieving exceptionally high ART coverage involves reaching groups that are difficult to target for testing and treatment. We estimate substantially lower ART coverage among men across most of sub-Saharan Africa than in other regions, which could stem from tendencies among men to delay presentation to testing and care.\textsuperscript{32} Additionally, in many parts of sub-Saharan Africa and other high-burden locations, large rural catchment areas further compound barriers to HIV treatment services. Developments in the area of geospatial modelling point to emerging opportunities to improve access and delivery of health interventions at the population level.\textsuperscript{33}

Despite the substantial progress made in reducing HIV-related mortality globally, only a small number of
countries are on track to meet the 2020 and 2030 mortality targets. To accelerate the decrease in HIV-related mortality, prevention, early detection, and treatment of opportunistic infections such as tuberculosis should be a priority. Integration of services for HIV and tuberculosis, a leading cause of mortality among people living with HIV, is crucial as a strategy to increase linkage to HIV care and tackle the double burden of HIV and tuberculosis.39

These findings should be viewed in the context of global financing for HIV/AIDS. The excitement around the MDGs and the goal to achieve universal access to treatment for HIV/AIDS by 2010 catalysed substantial resources to tackle the epidemic. Our estimates are consistent with the positive results of such global investment. However, the current and future costs of HIV/AIDS interventions and the ability of stakeholders to meet global needs will affect the epidemic going forward.

Moreover, the costs of the epidemic are likely to change. In 2015, US$27·3 billion was spent globally on HIV/AIDS care and treatment, amounting to more than half (55·8%) of the $48·9 billion spent on HIV/AIDS annually.1 HIV care and treatment includes services in both inpatient and outpatient settings, financed primarily through government spending and externally sourced development assistance for health. With access to ART, extended lifespans could continue to increase the total number of people living with HIV and thus further increase demand for treatment. Although the development of new therapies might reduce the per-person cost to treat those living with HIV, drug resistance that is emerging alongside increased access to ART could compound progress by increasing the cost of treatment and necessitating additional resistance testing on a wider scale.40 Therefore, decision makers need to anticipate the costs of providing treatment and look to prioritise prevention to reduce future costs. The GBD Health Financing Collaborator Network assessed that the annualised rate of support per prevalent case had increased between 2000 and 2010 but had subsequently decreased between 2010 and 2015.41 The gap that exists between available resources and what is needed to achieve global targets will require renewed mobilisation of resources, otherwise the decrease in development assistance for HIV/AIDS could hinder progress.

Although UNAIDS and GBD use similar approaches to modelling the burden of HIV, key differences exist in data and methods. At the global level, UNAIDS and GBD estimate similar mortality and prevalence; however, GBD estimates slightly higher incidence.42 Incidence in recent years is difficult to estimate because of the paucity of data and need to infer incidence from prevalence data. Therefore, recent estimates are highly sensitive to model specification. For group 2 countries, one primary data difference is that the GBD uses vital registration data as an input for models, using a uniform approach to cleaning data, accounting for garbage coding, and generating full time-series estimates of HIV mortality with uncertainty. While some countries might use vital registration data when producing official UNAIDS estimates, not all countries with data of sufficient quality include it as an input in their model, and heterogeneous data processing restricts comparability. Another methodological difference is that for allocation of ART to different ages, sexes, and disease severity levels, UNAIDS uses an average of the expected number of deaths and the number of people in each untreated CD4 count group to allocate ART, whereas GBD uses a model to determine the association between a country’s economic status and the allocation of treatment.

Globally, more than one in eight new HIV infections occur in South Africa, making global trends highly sensitive to differences in estimates for South Africa. UNAIDS estimates for South Africa are based on a bespoke epidemic model (Thembisa), which differs in its complexity and input data from the model used for the rest of sub-Saharan Africa.34 The Thembisa-based model estimates a lower peak of incidence (13·81 in 1999 vs 14·58 per 1000 in 2000 in GBD estimates), a steeper decrease in incidence between 2007 and 2012 (–28% in UNAIDS estimates vs –12% in GBD estimates), and a slower decrease in incidence between 2012 and 2017 than GBD does (–28% in UNAIDS estimates vs –34% in GBD estimates).35 Similarly, the same model estimates a faster decrease in the number of deaths between 2007 and 2012 (–50% in UNAIDS estimates vs –23% in GBD estimates), and a slower decrease in deaths between 2012 and 2017 (–29% in UNAIDS estimates vs –45% in GBD estimates).36

This study has several limitations. First, our incidence and prevalence estimates in countries with vital registration data are driven by back-estimation from mortality data using assumptions of disease progression and survival. This estimation process relies on knowledge of the distribution of deaths occurring in each year for each incidence cohort. The back-calculation is inherently uncertain in more recent years when a smaller proportion of each incidence cohort has died. Second, for countries without prevalence data for which we do not run EPP, we must run a first stage of Spectrum using input incidence estimates. Our final prevalence results have shown considerable sensitivity to this initial incidence. We have attempted to mitigate this sensitivity by testing several options for input incidence and selecting the one that produces the closest fit to mortality data for each location, yet we expect that sensitivity to input incidence might still result in overestimated HIV burden in some locations, such as Portugal. Third, in group 1 countries, we have little cause-specific mortality data and rely on prevalence data and HIV mortality data derived from cohort studies to model HIV deaths. This limitation is reflected by wider UIs for results in these locations. For on-ART mortality, we pooled data from across countries...
in sub-Saharan Africa, and although this process results in reliable regional estimates, it means that our model does not incorporate variation in treatment quality or health system access by country. Fourth, importantly, our estimates are subject to the data available at the time of analysis. New data sources will be incorporated in future iterations of analyses as they become available. Finally, although our forecasted incidence accounts for direct effects of ART in reducing a first generation of transmission, they do not incorporate compounding secondary transmission dynamic effects.

Despite these limitations, we made several improvements in our methods compared with previous GBD analyses. In GBD 2017, we modelled ART coverage distribution in Spectrum as a function of national wealth and disease progression. Whereas previous iterations of GBD used a version of Spectrum that disproportionately allocated ART to those with lower CD4 counts, the new model reflects earlier access to treatment regardless of disease progression for people living with HIV in higher-income countries. We also improved our estimation of paediatric HIV burden by modelling natural disease progression and informing child ART initiation and mortality using cohort data. Additionally, previous iterations assumed the same sex distribution of HIV incidence from the GBD 2017 study provides an estimate of ART in reducing a first generation of mortality using cohort data. Additionally, previous iterations assumed the same sex distribution of HIV burden across countries with generalised epidemics, but we now use a model fit to the sex ratio of prevalence from representative surveys to better reflect geographical variation.

Despite the considerable progress made in reducing HIV-related mortality and increasing the coverage of ART, HIV continues to be an enormous health burden globally. Up-to-date information on the trends of the HIV epidemic from the GBD 2017 study provides an opportunity to track the success of HIV control efforts and understand where interventions are having an impact. Our results show that decreases in mortality have out-paced decreases in incidence, therefore much needs to be done to prevent new cases of HIV. Additionally, at their current rates, many countries are not on track to reach the 2020 and 2030 UNAIDS and SDG targets. To truly end the HIV epidemic, the pace of progress needs to increase. Strides in this direction can be made by continuing to expand universal access to ART and increasing investments in proven HIV prevention initiatives that can scale to have population-level effects.

**Contributors**

C J L Murray, H H K Kyu, T D Frank, A Carter, D Jahagirdar, M H Biehl, M Arora, and S L Larson prepared the first draft. C J L Murray and H H K Kyu provided overall guidance. M H Biehl managed the project. T D Frank, A Carter, D Douwes-Schultz, and D Jahagirdar analysed the data. C J L Murray, H H K Kyu, T D Frank, A Carter, D Jahagirdar, M H Biehl, M Arora, and S L Larson finalised the manuscript on the basis of comments from other authors and reviewer feedback. All other authors provided data, developed models, reviewed results, provided guidance on methods, or reviewed the manuscript.

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Declaration of interests

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Data sharing

This study is compliant with GATHER, and data and code for the GBD 2017 HIV estimation process are available online.

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