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Global, regional and country-level 90–90–90 estimates for 2018: assessing progress towards the 2020 target

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Background: In 2014, the Joint United Nations Programme on HIV/AIDS (UNAIDS) and partners set the 90–90–90 target for the year 2020: diagnose 90% of all people living with HIV (PLHIV); treat 90% of people who know their status; and suppress the virus in 90% of people on treatment. In 2015, countries began reporting to UNAIDS on progress against 90–90–90 using standard definitions and methods.

Methods: We used data submitted to UNAIDS from 170 countries to assess country-specific progress towards 90–90–90 through 2018. To assess global and regional progress, overall and by sex for adults aged 15 years and older, we combined country-reported data with estimates generated with a Bayesian hierarchical model.

Results: A total of 60 countries reported on all three 90s in 2018, up from 23 in 2015. Among all PLHIV worldwide, 79% (67–92%) knew their HIV status. Of these, 78% (69–82%) were accessing treatment and 86% (72–92%) of people accessing treatment had suppressed viral loads. Of the 37.9 million (32.7–44.0 million) PLHIV worldwide, 53% (43–63%) had suppressed viral loads. The gap to fully achieving 73% of PLHIV with suppressed viral load was 7.7 million; 15 countries had already achieved this target by 2018.

Conclusion: Increased data availability has led to improved measures of country and global progress towards the 90–90–90 target. Although gains in access to testing and treatment continue, many countries and regions are unlikely to reach the 90–90–90 target by 2020.

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Background

Over the last two decades, a growing number of studies in diverse settings have demonstrated that antiretroviral treatment (ART) can play a dual role in improving the health of people living with HIV (PLHIV) and reducing onward transmission [1–7]. The Joint United Nations Programme on HIV and AIDS (UNAIDS) and the WHO have encouraged countries and global partners to translate evidence of ART's benefits from research studies into routine practice through a series of increasingly ambitious target setting initiatives [8,9]. With the goal of ending the AIDS epidemic by 2030, UNAIDS launched the 90–90–90 target in 2014: by 2020, 90% of PLHIV know their HIV status; 90% of all people with diagnosed HIV infection are on antiretroviral therapy; and 90% of people

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accessing treatment have suppressed viral load [10]. Mathematical modelling suggests that front-loading resources to reach 90–90–90 by 2020, with a further increase to 95–95–95 and the scale-up of other prevention measures by 2030, can reduce new HIV infections and AIDS deaths worldwide by 90% between 2010 and 2030 [11].

Routinely assessing country-level, regional and global progress towards 90–90–90 is critical to determining progress. Identifying gaps can help countries make necessary course-corrections to improve and expand service delivery where needed. However, studies have highlighted the many challenges of monitoring progress towards 90–90–90 in the early years of the initiative, including discrepancies in reported data, limited data availability in the public domain and lack of cross-country comparability of cascades [12,13]. Since 2015, countries have reported annually to UNAIDS on each prong of the 90–90–90 target following standardized reporting methodologies, including revising historical data as needed [14]. In this article, we describe these reporting methods and the data submitted to UNAIDS through 2018 (the latest reporting year). We also report national-level achievements and estimates of global and regional progress towards the 2020 target overall and by sex for adults 15 years of age and older.

Methods

Data sources and methods for constructing national measures of 90–90–90

We used the latest modelled estimates of PLHIV and data provided annually by 170 countries to UNAIDS for the years 2015–2018 on the estimated numbers of PLHIV who know their HIV status, who are on treatment and who are virally suppressed to construct national measures of progress towards 90–90–90. The 170 countries that contribute to UNAIDS global HIV estimates represent approximately 99% of the total 2018 population worldwide.

Progress towards 90–90–90 and the HIV testing cascade (measured as a proportion of all PLHIV) was calculated as described in Table 1. Where available, estimates were calculated separately for children (0–14 years) and adults (15 years and older by sex) and aggregated across all age groups.

Standard methods and accepted sources for reporting against the 90–90–90 target have been published by UNAIDS since 2016 and are described briefly below. Additional methodological considerations are found in the 2019 Global AIDS Monitoring guidelines [14].

People living with HIV estimates

Most countries reported mid-year estimates of the number of PLHIV by age and sex using the Spectrum modelling tool. For a small number of countries, primarily in high-income countries in Europe, Brazil and the United States, as well as in South Africa, other bespoke models are used to estimate PLHIV and Spectrum files are developed to match the modelled results [15–17]. Published country estimates of the number of PLHIV in 2018 were available for 79% of the estimated total PLHIV worldwide. More detail on using Spectrum to estimate the number of PLHIV can be found elsewhere in this supplement [18,19].

Table 1. 90–90–90 Definitions and targets.

		Calculation method			
Indicator	Definition	Numerator	Denominator	2020 Target (%)	2030 Target (%)
The first 90	Per cent of all people living with HIV who know their HIV status	Number of people living with HIV who know their status	Number of people estimated to be living with HIV	90	95
The second 90	Per cent of all people who are on treatment among those who know their HIV status	Number of people who are on ART	Number of people living with HIV who know their status	90	95
The third 90	Per cent of all people who are virally suppressed among those who are on treatment	Number of people who are virally suppressed	Number of people who are on ART	90	95
ART coverage[a]	Per cent of all people living with HIV who are on ART	Number of people who are on ART	Number of people estimated to be living with HIV	81	90
Viral suppression[a]	Per cent of all people living with HIV who are virally suppressed	Number of people who are virally suppressed	Number of people estimated to be living with HIV	73	86

ART, antiretroviral treatment.
[a]When taken together, the first 90, ART coverage and viral suppression are called the HIV testing and treatment cascade.

People living with HIV who know their HIV status
Countries used one of three different methods to report on the number of PLHIV who know their status at end-year. Most countries in sub-Saharan Africa used a UNAIDS supported 'Shiny90' model to estimate this outcome for the current year and for historical trends from 2010 [20]. The model uses HIV incidence, prevalence and ART coverage from the national Spectrum file, data about the proportion ever tested for HIV by HIV status from national population surveys, and where available, HIV testing and positivity programme data to estimate the proportion of PLHIV aware of their status over time. More details on this approach are provided elsewhere in this supplement [20].

Estimates in most countries outside of sub-Saharan Africa were calculated directly from HIV surveillance systems by subtracting the cumulative number of deaths among people diagnosed with HIV from the cumulative number of people diagnosed. To use this method, the national HIV surveillance system should have been functioning since at least 2013 and people who died, emigrated or who otherwise were lost to follow-up must be removed. In a third approach used by selected countries in Europe and North America, incidence, prevalence and the proportion of the undiagnosed population was modelled from case surveillance data, clinical information about disease progression and assumptions around HIV diagnoses rates [15,17].

People on treatment
Data on the number of people on treatment at the end of the reporting year were typically abstracted from routine health information systems, monthly programme reports, pharmaceutical records or from case surveillance systems by the country teams that work on HIV estimates. Since treatment numbers are critical to estimating PLHIV, AIDS mortality and other impact indicators accurately in Spectrum, these data are available for almost all 170 countries. For a small number of countries where reported numbers of people on treatment were not available from programme data – primarily in western and central Europe and North America – estimates of the number of people on treatment were developed either in consultation with the public health agency responsible for monitoring the national treatment programme or based on other published sources.

People virally suppressed
Estimates of the number of people suppressed at end-year were primarily collected from laboratory, case surveillance or programme reports. Some countries may triangulate programme data with direct measures from national population-based or HIV drug resistance surveys in the survey year. The reporting threshold for suppression is less than 1000 copies/ml, although some countries report against lower thresholds [21]. Currently, UNAIDS recommends that countries with viral load testing coverage between 50% and 90% assume that viral suppression in the untested and tested populations are the same when calculating suppression levels among all people on treatment. Above 90%, no further adjustments are required because testing is assumed to be universally available.

Exclusion criteria for country-submitted data
Country-provided data that do not meet basic checks for internal consistency across the cascade (e.g. the number of people who know their status exceeded the number of PLHIV) or that are unexplainably inconsistent with other reporting sources (e.g. the number of people reported to be virally suppressed by the Ministry of Health was lower than national population survey estimates during the same time period) were excluded. Viral load suppression results from routine programme data were only included for countries where access to routine testing was performed for at least 50% of PLHIV on ART.

Uncertainty around country estimates of 90–90–90
Upper and lower ranges of uncertainty for country-level estimates were calculated from the range of estimated numbers of PLHIV. This range does not fully capture uncertainty in the numbers of people who know their HIV status, who are on treatment and who are virally suppressed. Uncertainty in these data will vary by country and data source.

Methods for estimating regional and global progress towards 90–90–90

To calculate regional and global estimates of 90–90–90, a Bayesian hierarchical model based on regional trends, sex differences and country data (where countries reported data for some but not all years) was used to impute missing data for the first and third 90s. Estimates of knowledge of status were imputed in two steps. First, the logit of the proportion aware among PLHIV not on treatment was modelled using a two-level hierarchical structure with fixed effects for linear time trend and age-sex (children 0–14 years of age, men 15 years of age and older, women 15 years of age and older), region-level random effects for intercept, time trend and age-sex, and country-level random intercepts and age-sex effects. Second, the estimated proportion of PLHIV aware of status in this population was added to the proportion on treatment. To impute missing viral load suppression data for the third 90, the logit of viral suppression was modelled using the same two-level hierarchical model used to estimate knowledge of status. Posterior distributions for each 90 were estimated using the 'rstanarm' package for applied Bayesian regression modelling in the Statistical software R (R Foundation for Statistical Computing, Vienna, Austria) [22].

For each imputed country estimate of either the first or third 90, 2000 values were drawn from the posterior distribution. Regional and global averages and trends

were calculated by combining the 2000 draws with available country data. Given the significantly higher proportion of people virally suppressed in western and central Europe compared with the United States for the years in which data were available, subregional estimates for North America and western and central Europe were separately determined and then combined to produce the results for the region of western and central Europe and North America. Table S1 shows the proportion of imputed estimates for the first and third 90 between 2015 and 2018; http://links.lww.com/QAD/B525.

Upper and lower global and regional uncertainty ranges were calculated using the uncertainty in the number of PLHIV and from missing data. Uncertainty in treatment numbers of a 4% under-report or a 12% over-report was incorporated into uncertainty in the second and third 90s and ART coverage. These values were constructed from published and unpublished data quality reviews made available to UNAIDS prior to 2017 [23,24].

Results

Country progress towards 90–90–90

Complete HIV testing and treatment data to monitor 90–90–90 were available for 75 of the 170 countries in at least one of the four reporting years between 2015 and 2018. Sixty countries had complete cascades as of 2018 (Table 2). The number of countries able to report on any one prong of 90–90–90 increased substantially across reporting years, although viral suppression data were still available in only 76 countries in 2018.

Country progress towards 90–90–90 varied across regions and over time (refer to Table 3 for 2018 outcomes and Table S1 for 2015–2018 results; http://links.lww.com/QAD/B525). The latest country data through 2018 show that 15 countries reported meeting the viral suppression target among all PLHIV of 73%. These included Australia, Botswana, Cambodia, Denmark, Eswatini, France, Germany, Iceland, Ireland, Namibia, Netherlands, Rwanda, Spain, Thailand and the United Kingdom. Among these, six countries reported achieving each of the 90–90–90 prongs, including three countries (Botswana, Eswatini and Namibia) in southern Africa. For countries able to report in 2015 and 2018, 10 (Comoros, Guyana, Armenia, Tajikistan, Thailand, Cote d'Ivoire, Mexico, Morocco, Niger and Kuwait) had absolute increases in knowledge of status of 10 percentage points or more, 44 had made similar gains for the second 90, and despite the fact that treatment suppression among people on treatment was already reasonably high in most countries even in 2015, a few counties such as Uruguay and Armenia reported substantial gains of over 10 percentage points or more during the four years. UNAIDS' website (www.aidsinfo.com) provides additional country-level disaggregated outcomes for 90–90–90 and the cascade among adults by sex and children.

Global and regional progress towards 90–90–90

In 2018, an estimated eight of 10 (79%; 67– 92%) PLHIV globally knew their HIV status. Among them, 78% (69– 82%) were accessing antiretroviral therapy, and 86% (72–92%) of people accessing treatment had suppressed viral loads (Fig. 1a). Although the number of people who know their HIV status and are on treatment has risen steadily between 2015 and 2018, viral suppression among those on treatment has remained relatively stable.

Of the 37.9 million (32.7–44.0 million) PLHIV globally, 62% (46–74%) were on treatment and over half [53% (42–63%)] had suppressed viral loads (Fig. 1b). Despite steady gains in treatment coverage reaching 23.3 million (20.5-24.3 million) in 2018, an annual increase of more than 3.3 million per year would be required to meet the 81% target for 2020. Average year-on-year increases since 2015 have been 2.0 million. The gap to fully achieving the global target of 73% of all PLHIV with suppressed viral load was 7.7 million people in 2018, down from more than 12 million people in 2015.

There was substantial variation by region and by sex (Fig. 2). In Asia and the Pacific and the Caribbean, eastern Europe and central Asia, the Middle East and North Africa and western and central Africa, treatment coverage and viral suppression gaps as a proportion of all PLHIV remain large. In the Middle East and North Africa, the region with the poorest performance, among all PLHIV, less than half (47%; 26–80%) know their status, 29% (17–43%) were accessing antiretroviral therapy and 22% (13–32%) had suppressed viral load.

In contrast, the high-income region of western and central Europe and North America has nearly reached the target. Within this region, viral load suppression was near or above the first 90 threshold except in the United States, where the latest 2016 data showed low levels of viral load suppression among persons with diagnosed HIV infection [25,26]. In addition to the region of Western and central Europe and North America, eastern and southern Africa has made impressive gains toward the 90–90–90 target, with viral load suppression among all PLHIV increasing from 43% (37–50%) in 2015 to 58% (50–64%) in 2018. Latin America also appears to be moving towards achieving the 2020 viral suppression target at 55% (42–69%). Notably, though, progress has been slower in Latin America than eastern and southern Africa. Both regions had the same suppression levels among PLHIV in 2015.

Across all reporting years, estimates of all three 90s are lower for men than women, although these disparities are most pronounced in the first and second 90s (Fig. 1a). Regional variations are also evident. Knowledge of status

Table 2. Data availability for constructing national progress towards the 90–90–90 treatment target, by region, 2015–2018.

		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 (*n*)	2015–2018	38	16	21	16	17	20	25	40	193
Countries included in UNAIDS global estimates (*n*)	2015–2018	28	10	20	16	17	19	24	36	170
Countries with publicly available HIV estimates (*n*)	2015	20	9	20	12	16	15	24	23	139
	2016	20	9	20	12	16	15	24	24	140
	2017	20	9	20	12	16	15	24	23	139
	2018	20	9	20	12	16	15	24	21	137
Countries with publicly available data on the number of people living with HIV who know their status (*n*)	2015	8	6	20	7	6	6	18	9	80
	2016	9	6	20	8	8	6	18	18	93
	2017	12	7	20	9	8	6	18	18	98
	2018	15	6	20	12	9	9	18	13	102
Countries with publicly available data on the number of people living with HIV who are on treatment (*n*)	2015	20	9	20	13	16	15	24	21	138
	2016	20	9	20	13	16	15	24	23	140
	2017	21	9	20	13	16	15	24	24	142
	2018	22	9	20	14	16	17	24	21	143
Countries with publicly available data on the number of people living with HIV who are virally suppressed (*n*)	2015	5	0	3	5	4	4	1	4	26
	2016	5	2	8	5	7	4	1	13	45
	2017	7	4	7	8	8	6	3	12	55
	2018	9	7	13	11	11	9	6	10	76
Countries with complete HIV testing and treatment cascades (*n*)	2015	4	0	3	4	4	3	1	4	23
	2016	4	2	8	5	5	3	1	11	39
	2017	6	4	7	8	6	5	3	9	48
	2018	4	5	13	10	9	6	5	8	60

Table 3. Progress towards 90–90–90 and the HIV testing and treatment cascade, all ages, by country, region and global, 2018.[a]

	Estimates of people living with HIV and uncertainty bounds (*n*)	First 90: people living with HIV who know their status (%)	Second 90: people who are on ART among those who know their HIV status (%)	Third 90: people with suppressed viral load among those on ART (%)	ART coverage: people living with HIV who are treatment (%)	Viral suppression: people with suppressed viral load among all people living with HIV (%)
Global	37 900 000 (32 700 000–44 000 000)	79 (67–92)	78 (69–82)	86 (72–92)	62 (47–74)	53 (43–63)
Asia and the Pacific	5900 000 (5100 000–7100 000)	69 (59–85)	78 (68–83)	91 (72–100)	54 (41–68)	49 (38–63)
Afghanistan	7200 (41 00–11 000)	38 (21–60)	34 (19–54)	–	13 (7–20)	–
Australia	28 000 (23 000–31 000)	–	–	95 (81–>95)	83 (70–93)	79 (67–88)
Bangladesh	14 000 (12 000–16 000)	37 (32–42)	60 (53–68)	–	22 (19–25)	–
Bhutan	1300 (700–2700)	47 (25–>95)	79 (42–>95)	–	37 (20–78)	–
Brunei Darussalam	–	–	93 (86–>95)	59 (45–65)	–	–
Cambodia	73 000 (64 000–84 000)	82 (71–93)	>95 (86–>95)	95 (83–>95)	81 (71–93)	78 (67–89)
China	–	–	83 (75–93)	94 (85–>95)	–	–
Democratic People Republic of Korea	–	–	–	–	–	–
Fiji	–	–	–	–	–	–
India	–	–	–	–	–	–
Indonesia	640 000 (550 000–750 000)	51 (44–60)	33 (29–39)	–	17 (15–20)	–
Japan	30 000 (25 000–34 000)	–	–	–	80 (68–92)	–
Lao People Democratic Republic	12 000 (11 000–14 000)	85 (75–>95)	64 (56–73)	87 (77–>95)	54 (48–62)	47 (41–54)
Malaysia	87 000 (77 000–98 000)	86 (77–>95)	55 (49–62)	–	48 (42–53)	–
Maldives	–	–	–	–	–	–
Mongolia	600 (530–670)	38 (33–42)	86 (76–>95)	79 (70–88)	32 (29–36)	26 (23–29)
Myanmar	240 000 (210 000–270 000)	–	–	92 (82–>95)	70 (63–79)	65 (58–73)
Nepal	30 000 (26 000–34 000)	71 (63–82)	79 (70–91)	–	56 (50–65)	–
New Zealand	3600 (3100–4200)	–	–	–	73 (62–84)	–
Pakistan	160 000 (140 000–190 000)	14 (13–16)	69 (61–78)	–	10 (9–11)	–
Papua New Guinea	45 000 (41 000–50 000)	87 (77–95)	75 (67–82)	–	65 (58–71)	–
Philippines	77 000 (65 000–90 000)	76 (64–89)	57 (48–67)	–	44 (37–51)	–
Republic of Korea	–	–	–	–	–	–
Singapore	7900 (7200–8700)	–	–	–	78 (71–86)	–
Sri Lanka	3500 (3100–4000)	–	–	84 (74–>95)	45 (40–52)	38 (34–44)
Thailand	480 000 (420 000–550 000)	94 (82–>95)	80 (70–92)	>95 (85–>95)	75 (66–86)	73 (64–84)
Timor-Leste	–	–	–	–	–	–
Viet Nam	230 000 (200 000–260 000)	–	–	–	65 (57–73)	–
Caribbean	340 000 (290 000–390 000)	72 (60–86)	77 (66–81)	74 (53–85)	55 (42–67)	41 (28–52)
Bahamas	6000 (5300–6700)	–	–	–	52 (45–58)	–
Barbados	3000 (2700–3400)	–	–	88 (77–>95)	50 (44–57)	44 (39–50)
Belize	4900 (4400–5400)	49 (44–53)	58 (53–64)	65 (59–71)	28 (26–31)	18 (17–20)
Cuba	31 000 (24 000–37 000)	83 (64–>95)	86 (66–>95)	67 (52–80)	72 (55–85)	48 (37–57)
Dominican Republic	70 000 (54 000–92 000)	82 (64–>95)	68 (52–89)	67 (52–88)	56 (43–73)	37 (29–49)
Guyana	8200 (7200–9400)	93 (82–>95)	73 (64–84)	81 (71–92)	68 (60–78)	55 (48–63)
Haiti	160 000 (140 000–180 000)	67 (60–75)	86 (78–>95)	–	58 (52–65)	–
Jamaica	40 000 (35 000–46 000)	–	–	80 (70–91)	31 (27–36)	25 (22–29)
Suriname	5600 (3700–8100)	60 (40–86)	87 (58–>95)	87 (58–>95)	52 (35–75)	45 (30–65)
Trinidad and Tobago	–	–	–	–	–	–
Eastern and southern Africa	20 600 000 (18 200 000–23 200 000)	85 (75–95)	79 (69–82)	87 (74–92)	67 (52–78)	58 (50–66)
Angola	330 000 (290 000–390 000)	42 (36–50)	63 (54–75)	–	27 (23–31)	–
Botswana	370 000 (330 000–400 000)	91 (82–>95)	92 (83–>95)	>95 (88–>95)	83 (75–90)	81 (73–88)
Comoros	120 (60–240)	86 (43–>95)	91 (46–>95)	86 (43–>95)	79 (39–>95)	68 (34–>95)
Eritrea	18 000 (13 000–24 000)	82 (61–>95)	62 (46–84)	77 (57–>95)	51 (38–68)	39 (29–53)
Eswatini	210 000 (190 000–220 000)	92 (86–>95)	93 (87–>95)	94 (88–>95)	86 (80–94)	81 (76–89)
Ethiopia	690 000 (530 000–900 000)	79 (60–>95)	83 (63–>95)	–	65 (50–85)	–
Kenya	1600 000 (1300 000–1900 000)	89 (76–>95)	77 (65–92)	–	68 (58–82)	–
Lesotho	340 000 (320 000–360 000)	86 (80–92)	71 (66–76)	93 (87–>95)	61 (57–65)	57 (53–60)
Madagascar	39 000 (30 000–55 000)	11 (8–15)	84 (65–>95)	–	9 (7–13)	–
Malawi	1000 000 (940 000–1100 000)	90 (80–>95)	87 (78–94)	89 (80–>95)	78 (70–84)	69 (62–75)
Mauritius	13 000 (10 000–15 000)	22 (18–26)	>95 (82–>95)	73 (60–87)	22 (18–26)	16 (13–19)
Mozambique	2200 000 (1700 000–2700 000)	72 (58–89)	77 (62–95)	–	56 (44–68)	–

Table 3 (*continued*)

	Estimates of people living with HIV and uncertainty bounds (*n*)	First 90: people living with HIV who know their status (%)	Second 90: people who are on ART among those who know their HIV status (%)	Third 90: people with suppressed viral load among those on ART (%)	ART coverage: people living with HIV who are treatment (%)	Viral suppression: people with suppressed viral load among all people living with HIV (%)
Namibia	200 000 (190 000–220 000)	91 (84–>95)	>95 (93–>95)	95 (87–>95)	92 (84–>95)	87 (80–94)
Rwanda	220 000 (200 000–250 000)	94 (83–>95)	93 (81–>95)	85 (75–95)	87 (76–>95)	74 (65–82)
South Africa	7700 000 (7100 000–8300 000)	90 (83–>95)	68 (62–73)	87 (80–93)	62 (57–66)	54 (49–58)
South Sudan	190 000 (140 000–240 000)	24 (18–30)	66 (48–82)	–	16 (12–20)	–
Uganda	1400 000 (1300 000–1500 000)	84 (78–90)	87 (81–93)	88 (83–95)	72 (68–78)	64 (60–69)
United Republic of Tanzania	1600 000 (1400 000–1700 000)	78 (70–85)	92 (83–>95)	87 (78–95)	71 (64–78)	62 (56–68)
Zambia	1200 000 (1100 000–1400 000)	87 (78–>95)	89 (80–>95)	75 (67–85)	78 (69–88)	59 (52–66)
Zimbabwe	1300 000 (1100 000–1500 000)	90 (78–>95)	>95 (85–>95)	–	88 (77–>95)	–
Eastern Europe and central Asia	1700 000 (1500 000–1900 000)	72 (64–81)	53 (45–56)	77 (67–81)	38 (30–44)	29 (26–33)
Albania	–	–	62 (59–65)	–	–	–
Armenia	3500 (3000–4400)	73 (61–90)	72 (60–90)	83 (69–>95)	53 (44–65)	44 (36–54)
Azerbaijan	–	–	71 (50–>95)	75 (53–>95)	–	–
Belarus	27 000 (22 000–34 000)	79 (65–>95)	74 (61–95)	69 (56–88)	59 (48–75)	40 (33–52)
Bosnia and Herzegovina	320 (270–370)	–	–	–	67 (57–78)	–
Georgia	9400 (8100–11 000)	59 (51–68)	84 (72–>95)	85 (74–>95)	49 (42–57)	42 (36–49)
Kazakhstan	26 000 (24 000–27 000)	88 (81–94)	66 (61–71)	65 (60–69)	58 (54–62)	38 (35–40)
Kyrgyzstan	8500 (6500–12 000)	68 (52–92)	64 (48–86)	68 (52–93)	43 (33–59)	30 (22–40)
Montenegro	400 (330–460)	55 (46–64)	73 (61–84)	93 (78–>95)	40 (34–46)	38 (31–43)
North Macedonia	440 (390–520)	59 (51–69)	91 (80–>95)	86 (75–>95)	54 (47–63)	46 (40–54)
Republic of Moldova	17 000 (14 000–23 000)	54 (43–70)	63 (51–83)	77 (61–>95)	34 (27–45)	26 (21–34)
Russian Federation	–	–	–	–	–	–
Tajikistan	13 000 (11 000–16 000)	58 (47–70)	80 (66–>95)	67 (55–81)	46 (38–56)	31 (25–38)
Turkmenistan	–	–	–	–	–	–
Ukraine	240 000 (220 000–260 000)	71 (66–77)	73 (68–78)	93 (86–>95)	52 (48–56)	48 (45–52)
Uzbekistan	52 000 (48 000–56 000)	–	–	–	51 (47–55)	–
Latin America	1900 000 (1600 000–2400 000)	80 (62–99)	78 (67–84)	89 (74–96)	62 (44–78)	55 (42–69)
Argentina	140 000 (130 000–150 000)	–	–	–	61 (55–67)	–
Bolivia	22 000 (20 000–24 000)	–	–	74 (67–81)	44 (40–48)	33 (30–36)
Brazil	900 000 (690 000–1100 000)	85 (66–>95)	77 (60–>95)	94 (72–>95)	66 (51–82)	62 (47–77)
Chile	71 000 (63 000–78 000)	–	–	–	63 (56–70)	–
Colombia	160 000 (130 000–180 000)	–	–	–	73 (60–86)	–
Costa Rica	15 000 (13 000–17 000)	–	–	–	49 (44–54)	–
Ecuador	44 000 (29 000–71 000)	76 (51–>95)	75 (50–>95)	89 (59–>95)	57 (38–93)	51 (34–83)
El Salvador	25 000 (21 000–30 000)	74 (61–87)	63 (52–73)	85 (70–>95)	47 (39–55)	40 (33–46)
Guatemala	47 000 (43 000–51 000)	62 (57–68)	69 (64–75)	80 (74–87)	43 (40–47)	34 (32–37)
Honduras	23 000 (18 000–28 000)	60 (47–72)	85 (67–>95)	83 (66–>95)	50 (40–61)	42 (33–51)
Mexico	230 000 (200 000–270 000)	76 (65–86)	93 (79–>95)	89 (76–>95)	70 (60–80)	63 (53–71)
Nicaragua	9400 (7600–12 000)	–	–	74 (60–>95)	53 (43–68)	40 (32–51)
Panama	26 000 (24 000–29 000)	70 (64–77)	76 (69–84)	76 (68–83)	54 (48–59)	41 (37–45)
Paraguay	21 000 (16 000–31 000)	71 (54–>95)	57 (44–82)	79 (61–>95)	40 (31–58)	32 (25–46)
Peru	79 000 (58 000–110 000)	–	–	–	73 (54–>95)	–
Uruguay	14 000 (9900–19 000)	82 (58–>95)	70 (49–92)	86 (61–>95)	58 (41–76)	50 (35–65)
Venezuela	120 000 (100 000–130 000)	–	–	–	(<15–59)	–
Middle East and North Africa	240 000 (160 000–390 000)	47 (26–80)	69 (55–79)	82 (65–90)	32 (18–54)	27 (15–44)
Algeria	16 000 (15 000–17 000)	86 (81–92)	93 (87–>95)	68 (64–72)	81 (75–86)	55 (51–58)
Bahrain	–	–	–	–	–	–
Djibouti	8800 (7100–11 000)	–	–	–	30 (25–38)	–
Egypt	22 000 (20 000–24 000)	–	–	–	31 (28–33)	–
Iran (Islamic Republic of)	61 000 (34 000–120 000)	36 (20–69)	57 (32–>95)	82 (45–>95)	20 (11–39)	17 (9–32)
Jordan	370 (340–420)	–	–	–	84 (76–95)	–
Kuwait	640 (580–700)	67 (60–73)	92 (83–>95)	>95 (87–>95)	62 (55–67)	60 (54–65)
Lebanon	2500 (2200–2800)	91 (80–>95)	66 (58–73)	92 (81–>95)	60 (53–67)	56 (49–62)
Libyan Arab Jamahiriya	9200 (8300–10 000)	–	–	–	44 (40–49)	–
Morocco	21 000 (17 000–28 000)	76 (60–>95)	86 (68–>95)	91 (73–>95)	65 (52–86)	59 (47–78)
Oman	3200 (2900–3600)	48 (44–53)	84 (76–92)	87 (79–95)	41 (37–45)	35 (32–39)

Table 3 (*continued*)

	Estimates of people living with HIV and uncertainty bounds (*n*)	First 90: people living with HIV who know their status (%)	Second 90: people who are on ART among those who know their HIV status (%)	Third 90: people with suppressed viral load among those on ART (%)	ART coverage: people living with HIV who are treatment (%)	Viral suppression: people with suppressed viral load among all people living with HIV (%)
Qatar	–	–	>95 (85–>95)	73 (62–82)	–	–
Saudi Arabia	–	–	94 (82–>95)	94 (82–>95)	–	–
Somalia	11 000 (8400–15 000)	–	–	–	30 (23–41)	–
Sudan	59 000 (26 000–110 000)	27 (12–51)	56 (24–>95)	–	15 (7–28)	–
Syrian Arab Republic	660 (590–720)	–	–	–	20 (18–22)	–
Tunisia	2800 (1700–4400)	–	–	62 (38–>95)	39 (24–61)	24 (15–38)
United Arab Emirates	–	–	–	–	–	–
Yemen	11 000 (6500–18 000)	–	–	–	21 (12–35)	–
Western and central Africa	5000 000 (4000 000–6300 000)	64 (51–80)	79 (70–83)	76 (56–87)	51 (36–66)	39 (25–53)
Benin	73 000 (48 000–120 000)	–	–	79 (53–>95)	61 (40–>95)	48 (32–77)
Burkina Faso	96 000 (78 000–120 000)	70 (57–85)	88 (72–>95)	–	62 (50–75)	–
Burundi	82 000 (71 000–97 000)	–	–	–	80 (69–94)	–
Cameroon	540 000 (470 000–590 000)	74 (65–81)	71 (62–77)	–	52 (46–57)	–
Cape Verde	2400 (2100–2900)	>95 (81–>95)	92 (78–>95)	47 (40–56)	89 (75–>95)	42 (35–50)
Central African Republic	110 000 (90 000–140 000)	55 (46–69)	65 (54–81)	–	36 (30–45)	–
Chad	120 000 (94 000–150 000)	–	–	–	51 (40–63)	–
Congo	89 000 (69 000–120 000)	39 (30–51)	89 (69–>95)	–	35 (27–46)	–
Côte d' Ivoire	460 000 (360 000–580 000)	63 (50–80)	87 (69–>95)	75 (59–95)	55 (44–70)	41 (33–52)
Democratic Republic of the Congo	450 000 (370 000–530 000)	62 (51–73)	92 (75–>95)	–	57 (47–67)	–
Equatorial Guinea	62 000 (50 000–81 000)	49 (39–64)	69 (56–90)	–	34 (27–44)	–
Gabon	53 000 (43 000–67 000)	–	–	–	67 (54–85)	–
Gambia	26 000 (21 000–33 000)	36 (29–46)	81 (66–>95)	–	29 (24–38)	–
Ghana	330 000 (280 000–390 000)	57 (48–66)	59 (50–69)	–	34 (28–39)	–
Guinea	120 000 (100 000–140 000)	–	–	–	40 (34–48)	–
Guinea-Bissau	44 000 (39 000–49 000)	–	–	–	33 (29–37)	–
Liberia	39 000 (36 000–44 000)	68 (62–76)	52 (47–58)	–	35 (32–39)	–
Mali	150 000 (120 000–190 000)	33 (26–41)	93 (74–>95)	–	31 (25–39)	–
Mauritania	5600 (4500–7200)	62 (50–79)	88 (71–>95)	–	54 (44–69)	–
Niger	36 000 (30 000–43 000)	72 (60–86)	75 (63–90)	83 (69–>95)	54 (45–65)	45 (38–54)
Nigeria	1900 000 (1400 000–2600 000)	67 (49–89)	80 (59–>95)	80 (59–>95)	53 (40–71)	42 (32–57)
Senegal	42 000 (37 000–47 000)	65 (57–74)	>95 (84–>95)	–	63 (55–71)	–
Sierra Leone	70 000 (56 000–86 000)	49 (39–60)	83 (66–>95)	63 (50–77)	41 (33–50)	26 (21–32)
Togo	110 000 (100 000–120 000)	73 (68–79)	82 (77–89)	–	60 (56–65)	–
Western and central Europe and North America	2200 000 (1900 000–2400 000)	88 (75–99)	90 (78–95)	81 (69–87)	79 (61–92)	64 (54–74)
Austria	–	–	–	–	–	–
Belgium	–	–	–	–	–	–
Bulgaria	3500 (3000–4100)	83 (71–>95)	50 (43–58)	94 (80–>95)	41 (35–48)	39 (33–45)
Canada	–	–	–	–	–	–
Croatia	1600 (1400–1700)	–	–	90 (81–>95)	75 (67–83)	68 (61–75)
Cyprus	–	–	–	–	–	–
Czechia	4400 (3700–5000)	61 (51–69)	>95 (84–>95)	–	60 (51–68)	51 (43–58)
Denmark	6200 (5600–7000)	–	–	–	89 (79–>95)	–
Estonia	7400 (6600–8200)	83 (74–92)	71 (63–79)	90 (80–>95)	59 (53–66)	53 (48–59)
Finland	4000 (3100–4900)	91 (72–>95)	84 (66–>95)	88 (70–>95)	76 (60–95)	67 (53–83)
France	180 000 (150 000–210 000)	–	–	–	83 (69–>95)	–
Germany	87 000 (71 000–100 000)	–	–	–	80 (65–93)	–
Greece	–	–	–	–	–	–
Hungary	3700 (3200–4200)	90 (78–>95)	62 (54–70)	–	56 (48–63)	–
Iceland	320 (290–350)	80 (72–88)	>95 (88–>95)	95 (85–>95)	79 (71–87)	76 (67–83)
Ireland	7200 (6200–8000)	90 (78–>95)	89 (77–>95)	95 (82–>95)	80 (69–89)	76 (66–84)
Israel	9000 (8000–10 000)	–	–	–	–	–
Italy	130 000 (110 000–140 000)	–	–	–	91 (78–>95)	–
Latvia	5300 (4800–5900)	–	–	–	45 (41–50)	–

Table 3 (*continued*)

	Estimates of people living with HIV and uncertainty bounds (*n*)	First 90: people living with HIV who know their status (%)	Second 90: people who are on ART among those who know their HIV status (%)	Third 90: people with suppressed viral load among those on ART (%)	ART coverage: people living with HIV who are treatment (%)	Viral suppression: people with suppressed viral load among all people living with HIV (%)
Lithuania	–	–	–	–	–	–
Luxembourg	1200 (1000–1300)	86 (75–>95)	89 (78–>95)	89 (78–>95)	77 (67–86)	68 (60–76)
Malta	–	–	–	–	–	–
Netherlands	–	–	–	–	–	–
Norway	5800 (5200–6300)	>95 (88–>95)	84 (76–92)	–	82 (74–90)	–
Poland	–	–	–	–	–	–
Portugal	41 000 (36 000–46 000)	–	–	–	90 (78–>95)	–
Romania	18 000 (16 000–20 000)	87 (77–94)	78 (69–85)	80 (71–87)	67 (60–73)	54 (48–59)
Serbia	3000 (2200–3800)	86 (61–>95)	76 (54–>95)	–	65 (47–83)	–
Slovakia	1200 (910–1900)	69 (52–>95)	78 (59–>95)	86 (65–>95)	54 (40–85)	46 (35–73)
Slovenia	–	–	–	–	–	–
Spain	150 000 (130 000–170 000)	–	–	–	84 (73–94)	–
Sweden	–	–	–	–	–	–
Switzerland	–	–	>95 (85–>95)	>95 (87–>95)	–	–
Turkey	–	–	–	–	–	–
United Kingdom	–	–	–	–	–	–
United States of America	–	–	–	–	–	–

[a]*Source:* UNAIDS 2019 estimates. For additional data disaggregated by age and, for adults 15 years and older by sex and for historical data, please see aidsinfo.unaids.org.

among men is a full 20 percentage points lower than estimates among women in Eastern Europe and Central Asia and between 10 and 15% lower than the estimate among women in the Caribbean and western and central Africa. A comparison of trends between 2010 and 2018 for men and women in eastern and southern Africa and western and central Africa show men in the western and central African countries lagging the furthest behind in knowledge of status in recent years (Fig. 3). In Latin America and western and central Europe and North America, similar achievements by sex were observed for all three 90s.

Among children, estimates of knowledge of status are not available but for the remaining cascade, treatment coverage among children is 54% (37–73%) versus 62% (48–75%) among adults and viral suppression among children is just 41% (26–56%) versus 53% (44–63%) among adults. Intensive efforts in Eswatini, Namibia, Zambia and Zimbabwe have led to paediatric treatment levels of over 75%; however, elsewhere, especially in countries in western and central Africa, the disparity between adult and child treatment coverage is growing.

Discussion

The global commitment to scaling-up HIV testing and treatment programmes has accelerated the pace at which the world is moving to achieve 90–90–90. Despite this progress, it seems unlikely that many regions and countries will meet the 2020 target. As of 2018, approximately one in five PLHIV globally still do not know their HIV status, a further 22% of those who know their status are not accessing antiretroviral therapy and 14% of people on treatment do not yet have a suppressed viral load. Even with an absolute increase in the number of people on treatment from 15.1 million (13.3-15.7 million) in 2014 to 23.3 million (20.5-24.3 million) in 2018, the pace at which people access treatment needs to be even faster. Only modest improvements in viral suppression levels among people on treatment have been observed since the launch of the 90–90–90 target in contrast with the more substantial gains in knowledge of HIV status.

For many countries and regions, and within key subpopulations, examination of progress towards the 90–90–90 target and the gaps have provided useful information about what programme delivery improvements are needed [2,27–31]. Even in countries and regions where overall progress towards 73% viral load suppression among PLHIV has been achieved, including Namibia and Botswana, a significantly higher proportion of men are still unaware of their HIV status compared with women. In the Russian Federation, which has the largest burden of HIV in Eastern Europe and central Asia,

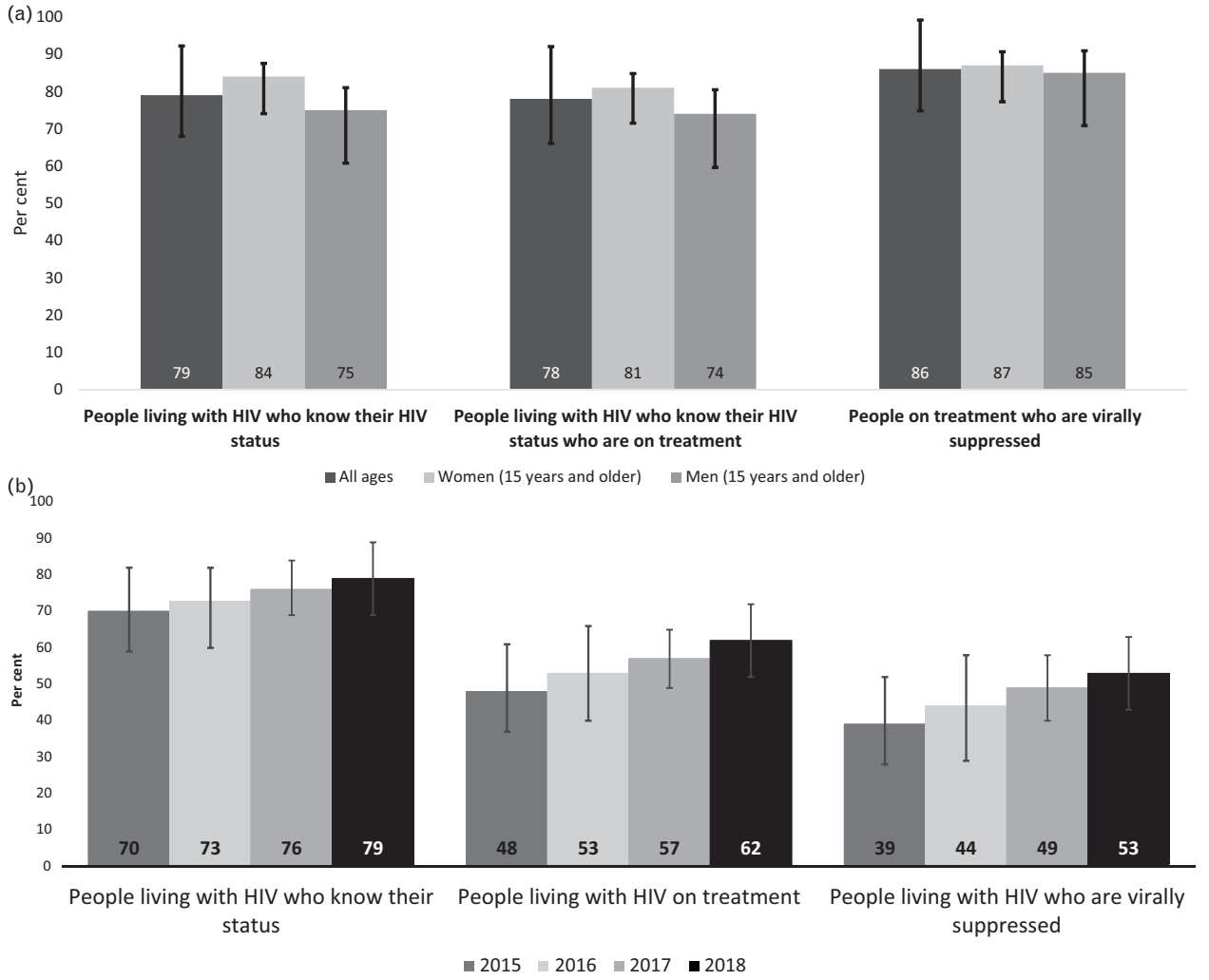

Fig. 1. (a) Progress towards 90–90–90, all ages and by sex for adults 15 years of age and older, global, 2018. (b) Progress along the HIV testing and treatment cascade, all ages, global, 2015–2018.

knowledge of status in previously reported estimates was thought to be high as a result of extensive testing, but linkage to treatment remains a challenge [32,33]. In the Middle East and North Africa, persistently low estimates of knowledge of HIV status and treatment access point to the role of stigma and discrimination in service delivery as possible causes [34,35]. For those who do overcome barriers to learning their status and initiating treatment, viral suppression levels in these regions are on par with high performing regions.

To reach the remaining groups of PLHIV who still do not know their status, innovative testing approaches, such as self-testing, index testing and delivery of testing through community-based services, will be required [36]. In generalized epidemics, these services are increasingly designed to reach people who otherwise might not seek HIV testing in health facilities, especially men and young people, as well as key population members and their partners. In concentrated epidemics, where HIV infections occur primarily in key populations and their partners, an optimized mix of routine and targeted testing services is needed. As more and more countries reach the 90–90–90 target, improved methods are needed to accurately collect information on how people may have acquired their infection to estimate progress towards the target among key populations [37].

With an additional 6.7 million people needing treatment by 2020 to meet the target, rapid expansion of proven models to get diagnosed individuals into care and, increasingly important, keep them on treatment are needed. Most countries have already benefitted from the treatment bump that stemmed from the early political and financial commitments from the U.S. Government President's Emergency Program for AIDS Relief (PEPFAR) and the Global Fund for AIDS, Tuberculosis and Malaria (Global Fund) [38]. Although near universal

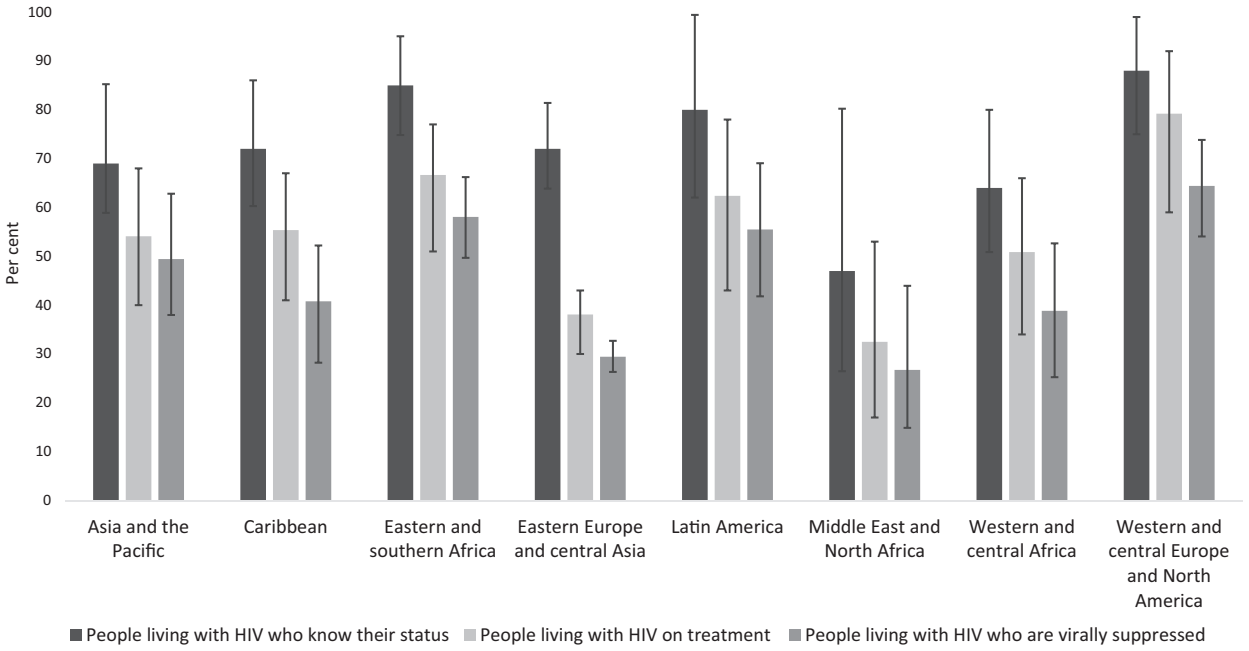

Fig. 2. HIV testing and treatment cascade, by region, 2018.

adoption of WHO's recommendation to 'treat all' by countries in 2016 has increased those who are eligible for ART [21], the rate of annual increase in numbers of people on treatment has not accelerated in recent years. In the SEARCH and HPTN071 (PopART) studies showed that using trained community health workers and providing an array of health services beyond HIV enable communities to reach the second 90 in sub-Saharan Africa [39,40]. Closing the ART coverage gap for children will require programmes that reach children after well child care visits end [11,12]. Finally, healthcare services need a user-friendly approach to supporting treatment among key populations who may feel stigmatized by healthcare workers when accessing testing and treatment services [13].

The modest gains in viral suppression through 2018 highlight the need for new strategies to support adherence and regimen switching when treatment failure is suspected. Although the availability of new medicines such as dolutegravir that offer a faster and sustained pathway to viral suppression (even among those who fail

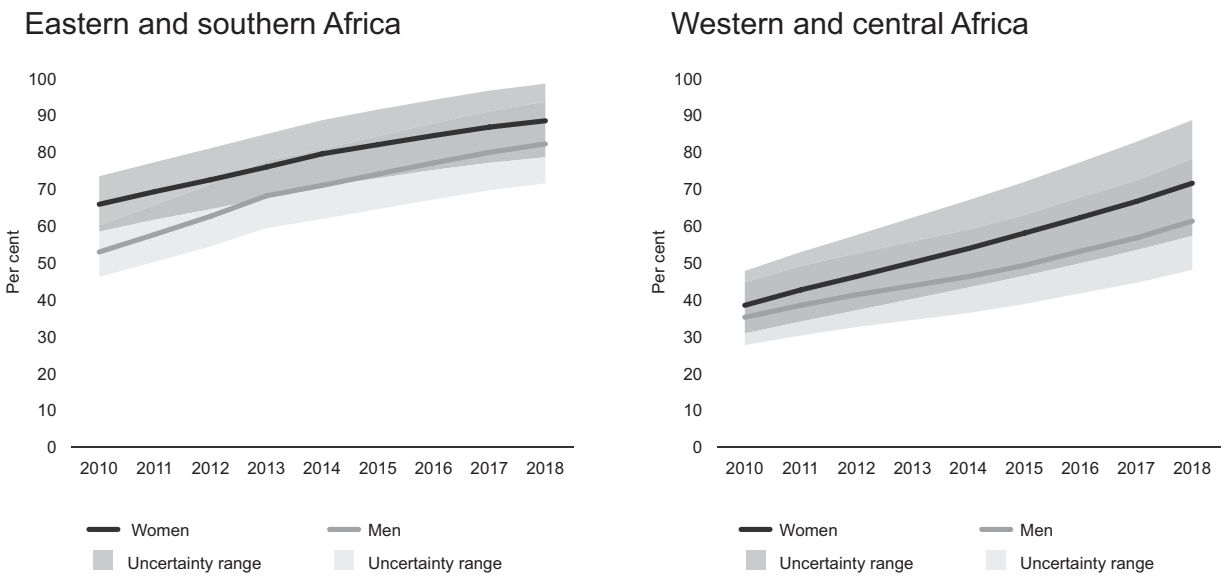

Fig. 3. Knowledge of HIV status among people living with HIV, by sex, Eastern and Southern Africa and Western and Central Africa, 2010–2018.

with older integrase inhibitors) will help, community-centred activities to help support adherence to treatment are paramount [2,41]. Strategies that use peers and trained community health workers have been shown to produce retention rates and treatment outcomes on par with those reported in traditional healthcare delivery settings [42–44]. Viral load testing is critical to identify patients who do not have suppressed viral load and initiate adherence support or a switch to second-line or third-line therapy, as appropriate.

Using the 90–90–90 estimates to identify and close gaps along the cascade requires tools that allow countries to accurately track outcomes. However, current approaches are subject to a number of potential limitations. For example, estimates across the cascade based on programme service registers may be understated if these registers are incomplete, or conversely, overstated if duplicate data are not detected and deleted. In addition, if people die or emigrate but are not removed from counts, achievements could be exaggerated. Many countries have recognized the potential for these inconsistencies and are actively taking steps to improve reporting systems. Between 2017 and 2019, most countries in sub-Saharan Africa have conducted or are in the process of conducting national data quality reviews using a standardized protocol to validate and correct current and historical treatment numbers where necessary [45]. The reported treatment numbers through 2018 are the first that incorporate results from these reviews.

Model-based national estimates of 90–90–90 (in particular for the first 90) also have been useful to assess country progress, although these approaches would benefit from further refinements. The new first 90 estimation model for sub-Saharan African, which triangulates data from HIV testing programmes and survey data about HIV testing history by age and sex, has markedly increased the availability of plausible estimates in the region, but more country-specific data on HIV testing and retesting behaviours is needed to validate expected yield (i.e. the number of truly new diagnoses) among those testing positive. In countries outside of sub-Saharan Africa where modelled estimates of the first 90 are based on case reports, data on $CD4^+$ cell count at diagnosis is critical to estimating the unreported fraction; in 42 countries in the WHO European Region, however, these data were reported in just 67% of diagnosed cases in 2017 [46]. In 2019, the European Centres for Disease Control developed an online tool that countries can use to impute missing values such as $CD4^+$ cell count to improve modelled estimates. Improved methods to estimate viral suppression in countries where testing access is limited are also needed.

Challenges also exist in accurately monitoring global and regional 90s. In previous years, estimates of progress in countries missing data was done using the ratio of knowledge of status and treatment for the first 90 and the ratio of the number of people suppressed among those on treatment in the region for countries where data were available. Because countries did not report in every year, however, these ratios fluctuated depending on the reporting year, making it difficult to compare trends over time. A benefit of the new hierarchical approach is that it can use reported data in whatever year they are available to estimate trends in and across the region. As with the previous approach, one primary limitation is that it is difficult to assess whether progress in countries with data is similar to that of countries without data. This is particularly true for viral load suppression estimates, where reported data in some regions including the Caribbean and Asia and Pacific – especially in 2015 and 2016 – are limited. As access to viral load testing improves over time, the accuracy of the estimates of the third 90 will improve.

While estimating progress towards 90–90–90 at all levels remain a challenge, the reported achievements have become the hallmark for measuring the success of the HIV response. Even after 2020, the framework of the 90–90–90 target remain paramount, signalling where additional investments and innovations in HIV testing and treatment programmes are needed to end the AIDS epidemic by 2030. The urgency over the next few years to focus on continued strengthening of systems and improved methods that will permit countries to accurately monitor these targets should not be underestimated.

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Conflicts of interest

There are no conflicts of interest.

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