






RESEARCH ARTICLE

Progress towards the UNAIDS 90-90-90 targets among persons aged 50 and older living with HIV in 13 African countries

Shannon M. Farley^{1,§} , Chunhui Wang¹, Rachel M. Bray¹, Andrea Jane Low^{1,2} , Stephen Delgado¹, David Hoos¹, Angela N. Kakishozi², Tiffany G. Harris^{1,2} , Rose Nyirenda³, Nellie Wadonda⁴, Michelle Li⁵, Mbaraka Amuri⁶, James Juma⁷, Nzali Kancheya⁸, Ismela Pietersen⁹, Nicholus Mutenda¹⁰, Salomo Natanael¹⁰, Appolonia Aoko¹¹, Evelyn W. Ngugi¹¹, Fred Asiimwe¹², Shirley Lecher¹² , Jennifer Ward¹³, Prisca Chikwanda¹⁴, Owen Mugurungi¹⁵, Brian Moyo¹⁵, Peter Nkurunziza¹, Dorothy Aibo¹, Andrew Kabala¹, Sam Biraro^{1,2}, Felix Ndagije¹, Godfrey Musuka¹ , Clement Ndongmo¹⁶, Judith Shang¹⁶, Emily K. Dokubo¹⁶, Laura E. Dimite¹⁶, Rachel McCullough-Sanden¹⁶, Anne-Cecile Bissek¹⁷, Yimam Getaneh¹⁸, Frehywot Eshetu¹⁹, Tapa Nkumbula¹, Lyson Tenthani¹, Felix R. Kayigamba¹, Wilford Kirungi²⁰, Joshua Musinguzi²⁰, Shirish Balachandra²¹, Eugenie Kayirangwa²², Ayiyi Ayite²³, Christine A. West²³, Stephane Bodika²³, Katrina Sleeman²³, Hetal K. Patel²³, Kristin Brown²³, Andrew C. Voetsch²³, Wafaa M. El-Sadr^{1,2} and Jessica J. Justman^{1,2}

§Corresponding author: Shannon M. Farley, ICAP at Columbia University, 722 W 168th St, 13th Floor, New York, NY 10032, USA. Tel: +1 415 845 8854. (smf2026@cumc.columbia.edu)

Abstract

Introduction: Achieving optimal HIV outcomes, as measured by global 90-90-90 targets, that is awareness of HIV-positive status, receipt of antiretroviral (ARV) therapy among aware and viral load (VL) suppression among those on ARVs, respectively, is critical. However, few data from sub-Saharan Africa (SSA) are available on older people (50+) living with HIV (OPLWH). We examined 90-90-90 progress by age, 15–49 (as a comparison) and 50+ years, with further analyses among 50+ (55–59, 60–64, 65+ vs. 50–54), in 13 countries (Cameroon, Cote d'Ivoire, Eswatini, Ethiopia, Kenya, Lesotho, Malawi, Namibia, Rwanda, Tanzania, Uganda, Zambia and Zimbabwe).

Methods: Using data from nationally representative Population-based HIV Impact Assessments, conducted between 2015 and 2019, participants from randomly selected households provided demographic and clinical information and whole blood specimens for HIV serology, VL and ARV testing. Survey weighted outcomes were estimated for 90-90-90 targets. Country-specific Poisson regression models examined 90-90-90 variation among OPLWH age strata.

Results: Analyses included 24,826 HIV-positive individuals (15–49 years: 20,170; 50+ years: 4656). The first, second and third 90 outcomes were achieved in 1, 10 and 5 countries, respectively, by those aged 15–49, while OPLWH achieved outcomes in 3, 13 and 12 countries, respectively. Among those aged 15–49, women were more likely to achieve 90-90-90 targets than men; however, among OPLWH, men were more likely to achieve first and third 90 targets than women, with second 90 achievement being equivalent. Country-specific 90-90-90 regression models among OPLWH demonstrated minimal variation by age stratum across 13 countries. Among OPLWH, no first 90 target differences were noted by age strata; three countries varied in the second 90 by older age strata but not in a consistent direction; one country showed higher achievement of the third 90 in an older age stratum.

Conclusions: While OPLWH in these 13 countries were slightly more likely than younger people to be aware of their HIV-positive status (first 90), this target was not achieved in most countries. However, OPLWH achieved treatment (second 90) and VL suppression (third 90) targets in more countries than PLWH <50. Findings support expanded HIV testing, prevention and treatment services to meet ongoing OPLWH health needs in SSA.

Keywords: ageing; HIV epidemiology; HIV testing; older PLHIV; PHIA; UNAIDS goals

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1 | INTRODUCTION

Persons living with HIV (PLWH), including those in low- and middle-income countries, have experienced extended life expectancies due to the success of antiretroviral (ARV) therapies [1]. In 2014, the Joint United Nations Programme on HIV and AIDS (UNAIDS) launched the 90-90-90 global targets for 2020: 90% of PLWH will know their HIV status (first 90); 90% of those aware will receive sustained ARV therapy (ART) (second 90); and of these, 90% will achieve viral load suppression (VLS) (third 90) [2], as a stepping stone towards achieving the end of the AIDS epidemic as a public health threat by 2030 with 95-95-95 global targets for 2025 [3, 4]. In 2019, a modelling study examined data released by UNAIDS and found that 60 out of 170 countries were able to report on all three 90 targets; many of these countries, however, were not likely to achieve 90-90-90 targets by 2020 although three countries in sub-Saharan Africa (SSA) were among the six that achieved the model targets [5]. Studies of HIV prevalence among older adults, 50 years of age and older (50+), have shown increases in the number of older persons living with HIV (OPLWH), in general, and particularly in Eastern and Southern Africa [1, 6, 7].

With this growing and ageing population of OPLWH, it is important to focus on older adults and their risk for HIV as well as to understand how OPLWH have progressed towards the UNAIDS 90-90-90 targets in SSA [8]. A recent systematic review and meta-analysis using data published between 2014 and 2018 among PLWH aged 15 and older that examined progress towards 90-90-90 targets by a range of socio-demographics found a mixed picture in SSA [9]. Both males and females have made progress towards achieving the 90-90-90 targets by age group. Women within each age group demonstrated more progress along the cascade overall compared with men, and older adults achieved more progress towards the 90-90-90 targets than younger age groups [9].

To date, measuring progress towards 90-90-90 among the OPLWH has been challenging for several reasons. First, studies examining HIV in SSA have largely focused on younger adults, despite the growth in the number of OPLWH [1, 6, 10, 11]. Secondly, not all studies have reported on all three 90s, usually focusing on one or two of the 90s, with more recent attempts examining all 90-90-90 targets [5, 12–15]. Thirdly, most studies that assessed 90-90-90 progress have relied on programmatic data, which are restricted to the subset of the population living with HIV who have accessed services, rather than the entirety of people living with HIV [16].

We examined 90-90-90 target achievement by age and sex using nationally representative samples of adults in 13 SSA countries: Cameroon, Cote d'Ivoire, Eswatini, Ethiopia, Kenya, Lesotho, Malawi, Namibia, Rwanda, Tanzania, Uganda, Zambia and Zimbabwe. We further assessed the progress towards 90-90-90 targets among subsets of individuals by age strata among OPLWH. Finally, we assessed the associations between age and achievement of the 90-90-90 targets among OPLWH, by country, using Poisson regression models, to inform efforts to address gaps in services for this population.

2 | METHODS

2.1 | Data source

Data for the 13 countries (Cameroon 2017–2018, Cote d'Ivoire 2017–2018, Eswatini 2016, Ethiopia 2017–2018, Kenya 2018, Lesotho 2016–2017, Malawi 2015–2016, Namibia 2017, Rwanda 2018–2019, Tanzania 2016–2017, Uganda 2016–2017, Zambia 2016 and Zimbabwe 2015–2016) were collected as part of the Population-based HIV Impact Assessment (PHIA) surveys between 2015 and 2019. The PHIA surveys selected a nationally representative sample using a stratified two-stage cluster sampling design to provide a population-level assessment of the burden of HIV at national and sub-national levels [17, 18]. The surveys were funded by the United States President's Emergency Plan for AIDS Relief (PEPFAR) and conducted by ministries of health with support from ICAP at Columbia University, the University of California at San Francisco (Namibia PHIA) and the US Centers for Disease Control and Prevention (CDC). The PHIA survey design and implementation have been previously described [18, 19]. At the time the PHIA surveys were conceived, the HIV burden varied across these countries among 15–49 year old; seven countries had an HIV prevalence ranging from 1.5% to 7.3% (Ethiopia—1.5%, Rwanda—3.0%, Cote d'Ivoire—3.7%, Cameroon—4.3%, Tanzania—5.3%, Kenya—5.6% and Uganda—7.3%); four countries had an HIV prevalence ranging from 10.6% to 15.0% (Malawi—10.6%, Namibia—14.3%, Zambia—14.3% and Zimbabwe—15.0%); and two countries had an HIV prevalence above 20% (Lesotho—23% and Eswatini—26%). The ARV coverage varied among these countries at that time as well; six countries had ARV coverage below 50% (Cote d'Ivoire—24.4%, Cameroon—26.0%, Lesotho—35.0%, Tanzania—37.0%, Ethiopia—40.0% and Uganda—40.0%); and seven countries had ARV coverage well above 50% (Zambia—76.9%, Kenya—78.5%, Eswatini—82.0%, Malawi—83.0%, Namibia—90.0%, Zambia—90.0% and Rwanda—91.0%) [20–32].

2.2 | Eligibility criteria and survey domains

Eligibility criteria for this analysis were based on age ≥ 15 years old and whether the person slept in the household the night before the interview. Upper age limits for individual eligibility varied by country: 59 years of age for Lesotho and Zambia, 64 years of age for Cameroon, Cote d'Ivoire, Ethiopia, Kenya, Malawi, Namibia, Rwanda and Uganda, and no upper age limit in Eswatini, Tanzania and Zimbabwe. Household and individual interviews were conducted among consenting individuals (minors provided informed assent), capturing demographic, behavioural and clinical data, including self-reported HIV status, testing history and medication uptake.

2.3 | Laboratory procedures

Consenting participants provided blood specimens for HIV diagnostic testing, using the national HIV rapid testing algorithm and counselling was provided to all survey participants in their homes. Blood specimens for all HIV-positive participants were further tested for CD4⁺ T-cell enumeration in

the household, viral load (VL) testing at central laboratories and qualitative testing for selected ARVs, at the University of Cape Town, South Africa. VL testing was performed on the Abbott *m2000* (Abbott Molecular, Des Plaines, IL, USA), the bioMérieux NucliSens EasyMag/EasyQ (bioMérieux, Marcy-l'Étoile, France) or the Roche COBAS AmpliPrep/COBAS TaqMan (Roche Diagnostics, Pleasanton, CA, USA) platforms. VLS was defined as <1000 copies/ml [33].

2.4 | Ethics approval

The surveys were approved by the Institutional Review Boards at Columbia University Irving Medical Center, the University of California at San Francisco (Namibia only), the CDC and the local ethics board in each country.

2.5 | Measures

We examined 90-90-90 progress by sex and age (15–49, 50+) in the 13 PHAs. The first 90 (HIV status awareness) outcome was defined as the proportion of participants who tested HIV positive during the PHAs, who self-reported being HIV positive during the interview, prior to learning the result of household HIV testing, or if ARVs were detected in their blood. The second 90 (ART use among aware) was defined as the proportion of aware participants who self-reported taking ARVs or had ARVs detected in their blood, and the third 90 (VLS) was defined as the proportion of ART users who have HIV-1 RNA <1000 copies/ml.

Descriptive statistics and model variables included basic demographics, such as sex, age groups (50–54, 55–59, 60–64, 65 and older), residence and other measures of socioeconomic status as well as a variety of treatment outcome variables.

2.6 | Analysis

We calculated 90-90-90 estimates by age (15–49 and 50+) and sex for each of the 13 countries, and accounted for survey design with Jackknife variance estimation. These analyses were performed with SAS version 9.4. We calculated weighted percentages to describe demographic characteristics, partner's HIV status, time since HIV diagnosis and time on ART, among OPLWH from all 13 countries, using the Taylor Series method on variance estimation. We pooled the variance strata and Primary Sampling Units recorded on the country-level data files, re-numbered strata to make unique ones, then produced the variance estimates with the Taylor Series linearization method in the pooled dataset. We fit three multivariate Poisson regression models per country, one for each of the 90-90-90 targets, among OPLWH, to examine how 90-90-90 progress varied by age strata among OPLWH (50–54, 55–59, 60–64, 65 and older) [34, 35]. We adjusted the first 90 models for sex, residence, employed, wealth quintile, education, marital status and partner HIV status-self-reported. We adjusted the second 90 models for the same variables as the first 90 models as well as the number of years since diagnosis. We adjusted the third 90 models for the same variables as the first 90 and the number of years since initiating ART. We reported adjusted prevalence ratios (aPR) to measure the association between these factors and the 90-90-90

outcomes. We constructed models using Stata 15. All comparisons reported are significant at $p < 0.05$.

3 | RESULTS

3.1 | 90-90-90 targets

A total of 20,170 PLWH 15–49 years of age and 4656 OPLWH 50+ were included in the analyses. Figure 1 shows the progress towards 90-90-90 targets for each of the 13 countries. The target for awareness of HIV-positive status (first 90) was achieved among women aged 15–49 and among 50+ (women and men) in Eswatini, among 50+ (women and men) in Namibia, as well as among men 50+ in Lesotho. The target for ARV treatment (second 90) was achieved among those aged 15–49 (women and men) in six countries and among women aged 15–49 in four other countries, while the target was achieved in all 13 countries among 50+ (women and men). The VLS target (third 90) was achieved by those aged 15–49 (women and men) in one country and by women aged 15–49 in three countries and men aged 15–49 in one country, while the VLS target was achieved among 50+ (women and men) in eight countries and men 50+ in three countries and women 50+ in one country. Among those aged 15–49, women were more likely to have achieved the 90-90-90 targets than men; however among those 50+, men were more likely to have achieved the first (3 countries vs. 2 countries, respectively) and third (11 countries vs. 9 countries, respectively) 90 targets than women, with second 90 achievement being equivalent.

3.2 | OPLWH demographics

Among all 4656 OPLWH from the 13 countries, as noted in Table 1, there were more women than men (56.42% vs. 43.68%) identified, with the majority of OPLWH in the 50–59 age range (50–54 years: 46.27%; 55–59 years: 32.55%), the majority resided in rural areas (60.89%) and were not currently employed (57.23%). The OPLWH had a similar wealth status as the general population, with 61.65% in the upper 60% wealth quintile for their country. Most men (78.71%) were married or living with a partner compared with just 26.69% of women, while almost half of women (47.27%) were widowed compared with just 8.60% of men. The highest level of educational completion for most (58.37%) was a primary school. Most (79.44%) of the women reported no partner in the household compared with 31.75% of men, while 39.40% of the men reported having one or more HIV-positive partners compared to 8.20% of the women. Among OPLWH, 66.09% of the women reported having no sexual partners in the past 12 months compared with 20.04% of men, and 36.05% of the men reported that one or more of their partners think/told/tested HIV positive compared with 10.44% of the women.

3.3 | OPLWH treatment status

Among all OPLWH in Table 2, 21.25% were unaware of their HIV-positive status. Among OPLWH, 27.21% did not have ARVs detected in their blood and 26.50% were not virally



Figure 1. Antiretroviral-adjusted 90-90-90 estimates among 15–49 and 50+ years, 13 countries, Population-based HIV Impact Assessments, 2015–2019.

Notes: - - - - - represents the 90-90-90 target; Survey dates: Cameroon 2017–2018, Cote d'Ivoire 2017–2018, Eswatini 2016, Ethiopia 2017–2018, Kenya 2018, Lesotho 2016–2017, Malawi 2015–2016, Namibia 2017, Rwanda 2018–2019, Tanzania 2016–2017, Uganda 2016–2017, Zambia 2016 and Zimbabwe 2015–2016.

Table 1. Pooled 13 country descriptive socio-demographic statistics among older persons living with HIV aged 50 and over

| | Males | | Females | | Total | |
|--|-------|---------------------|---------|---------------------|-------|---------------------|
| | N | % (95% CIs) | N | % (95% CIs) | N | % (95% CIs) |
| Sex | | | | | | |
| Male | | | | | 1911 | 43.58 (42.15–45.02) |
| Female | | | | | 2745 | 56.42 (54.98–57.85) |
| Age | | | | | | |
| 50–54 | 837 | 46.51 (44.01–49.01) | 1275 | 46.08 (44.07–48.09) | 2112 | 46.27 (44.73–47.81) |
| 55–59 | 606 | 32.73 (30.52–34.94) | 900 | 32.42 (30.64–34.19) | 1506 | 32.55 (31.11–34.00) |
| 60–64 ^a | 335 | 15.87 (14.45–17.3) | 437 | 16.83 (15.38–18.27) | 772 | 16.41 (15.41–17.42) |
| 65+ ^b | 133 | 4.89 (4.08–5.69) | 133 | 4.67 (3.67–5.67) | 266 | 4.77 (4.08–5.45) |
| Residence | | | | | | |
| Urban | 640 | 38.21 (36.11–40.30) | 939 | 39.81 (37.93–41.68) | 1579 | 39.11 (37.72–40.50) |
| Rural | 1271 | 61.79 (59.70–63.89) | 1806 | 60.19 (58.32–62.07) | 3077 | 60.89 (59.50–62.28) |
| Employed | | | | | | |
| Yes | 907 | 54.30 (52.06–56.54) | 799 | 33.85 (31.99–35.72) | 1706 | 42.77 (41.32–44.22) |
| No | 1004 | 45.70 (43.46–47.94) | 1943 | 66.15 (64.28–68.01) | 2947 | 57.23 (55.78–58.68) |
| Wealth quintile | | | | | | |
| Lower 40% | 802 | 35.95 (33.87–38.02) | 1288 | 40.20 (38.41–41.99) | 2090 | 38.35 (37.00–39.69) |
| Upper 60% | 1108 | 64.05 (61.98–66.13) | 1455 | 59.80 (58.01–61.59) | 2563 | 61.65 (60.31–63.00) |
| Marital status | | | | | | |
| Never married | 102 | 2.98 (2.35–3.61) | 276 | 6.28 (5.27–7.30) | 378 | 4.84 (4.24–5.45) |
| Married or living together | 1449 | 78.71 (76.86–80.56) | 764 | 26.69 (24.93–28.45) | 2213 | 49.36 (47.65–51.07) |
| Divorced or separated | 161 | 9.70 (8.26–11.14) | 389 | 19.76 (17.96–21.56) | 550 | 15.38 (14.05–16.71) |
| Widowed | 196 | 8.60 (7.35–9.85) | 1310 | 47.27 (45.33–49.21) | 1506 | 30.42 (29.02–31.81) |
| Education | | | | | | |
| None | 246 | 10.45 (9.03–11.87) | 551 | 26.02 (24.03–28.00) | 797 | 19.22 (17.88–20.55) |
| Primary | 1055 | 59.36 (57.20–61.52) | 1589 | 57.61 (55.62–59.59) | 2644 | 58.37 (56.79–59.96) |
| Post primary | 605 | 30.18 (28.16–32.21) | 592 | 16.38 (15.18–17.57) | 1197 | 22.41 (21.28–23.53) |
| Partner HIV status-measured | | | | | | |
| One or more partner HIV positive | 749 | 39.40 (37.27–41.53) | 265 | 8.20 (7.22–9.18) | 1014 | 21.80 (20.41–23.19) |
| All partners HIV positive | 393 | 23.96 (21.96–25.96) | 128 | 5.37 (4.53–6.20) | 521 | 13.47 (12.48–14.45) |
| Don't know or missing | 82 | 4.89 (3.88–5.89) | 191 | 6.99 (6.25–7.74) | 273 | 6.08 (5.47–6.68) |
| No partner in household | 687 | 31.75 (29.65–33.86) | 2161 | 79.44 (77.97–80.90) | 2848 | 58.65 (57.00–60.31) |
| Partner HIV status-self-reported | | | | | | |
| One or more partner think/told/tested HIV positive | 736 | 36.05 (33.84–38.26) | 387 | 10.44 (9.52–11.35) | 1123 | 21.52 (20.25–22.78) |
| All partners think/told/tested HIV negative | 359 | 20.47 (18.75–22.19) | 207 | 8.05 (6.99–9.10) | 566 | 13.42 (12.43–14.41) |
| Don't know or missing | 433 | 23.44 (21.45–25.42) | 455 | 15.43 (13.93–16.92) | 888 | 18.89 (17.58–20.21) |
| No partner in the past 12 months | 370 | 20.04 (17.94–22.14) | 1692 | 66.09 (64.09–68.09) | 2062 | 46.17 (44.29–48.05) |
| Country | | | | | | |
| Malawi | 155 | 9.16 (8.11–10.21) | 184 | 8.27 (7.44–9.10) | 339 | 8.66 (8.15–9.17) |
| Zambia | 148 | 8.79 (7.97–9.61) | 184 | 6.74 (6.03–7.46) | 332 | 7.64 (7.13–8.14) |
| Eswatini | 243 | 2.16 (1.91–2.41) | 337 | 1.69 (1.52–1.86) | 580 | 1.90 (1.76–2.04) |
| Tanzania | 149 | 17.76 (15.62–19.90) | 225 | 20.51 (18.84–22.18) | 374 | 19.31 (18.29–20.33) |
| Zimbabwe | 348 | 16.00 (14.46–17.55) | 428 | 11.95 (11.09–12.81) | 776 | 13.72 (12.91–14.53) |
| Uganda | 116 | 10.66 (9.73–11.59) | 167 | 10.34 (9.25–11.44) | 283 | 10.48 (9.76–11.20) |
| Lesotho | 209 | 3.03 (2.65–3.41) | 339 | 2.84 (2.60–3.09) | 548 | 2.92 (2.72–3.12) |
| Cameroon | 75 | 5.4 (4.67–6.13) | 113 | 6.28 (5.56–7.00) | 188 | 5.90 (5.35–6.45) |

(Continued)

Table 1. (Continued)

| | Males | | Females | | Total | |
|---------------|-------|---------------------|---------|---------------------|-------|---------------------|
| | N | % (95% CIs) | N | % (95% CIs) | N | % (95% CIs) |
| Namibia | 183 | 2.12 (1.85–2.38) | 311 | 2.34 (2.14–2.53) | 494 | 2.24 (2.10–2.38) |
| Cote d'Ivoire | 42 | 4.44 (3.68–5.19) | 65 | 6.26 (5.12–7.39) | 107 | 5.46 (4.79–6.13) |
| Ethiopia | 33 | 3.72 (3.12–4.32) | 52 | 3.22 (2.88–3.57) | 85 | 3.44 (3.13–3.75) |
| Kenya | 121 | 13.49 (12.10–14.88) | 203 | 16.19 (14.96–17.42) | 324 | 15.02 (14.23–15.80) |
| Rwanda | 89 | 3.27 (2.90–3.65) | 137 | 3.36 (3.04–3.68) | 226 | 3.32 (3.14–3.51) |

Note: Upper age limits varied by country.

^aExcludes Lesotho and Zambia.

^bIncludes only Eswatini, Tanzania and Zimbabwe.

On residence, Lesotho had three categories: urban, rural and peri-urban, and peri-urban was collapsed into urban, while in Ethiopia, small urban was classified as rural and large urban was classified as urban.

suppressed. More than one-third (37.04%) of OPLWH had a CD4⁺ cell count ≥ 500 per μl , 27.03% had a CD4⁺ cell count of 350–499 per μl , 22.71% had a CD4⁺ cell count of 200–349 per μl , 10.87% had a CD4⁺ count of 100–199 per μl and 2.36% had a CD4⁺ count of < 100 per μl . Of all OPLWH, 12.68% indicated that they were never tested for HIV before the survey, and among those who were aware of their HIV-positive status, 6.82% had been diagnosed within the past year. Almost all OPLWH (96.99%) with detectable ARVs in their blood were taking first-line ART regimens (guidance at the time of the surveys) and more than half (54.84%) of those on ART indicated that they initiated treatment 5 or more years prior to the survey.

3.4 | OPLWH country-specific Poisson regression

Table 3 shows the first 90 awareness models for all 13 countries. There were no significant differences in awareness of HIV-positive status by age stratum among OPLWH ($p > 0.05$). In Table 4, the second 90 on treatment models for all 13 countries are presented. Three countries showed variation in the second 90 by older age strata but not in a consistent direction. With regard to the second 90, in Eswatini, those aged 60–64 who were aware of their HIV-positive status were more likely to be on treatment than those aged 50–54 years old (aPR: 1.06, 95% confidence intervals [CI]: 1.01–1.11, $p < 0.05$). In Cameroon, those aged 60–64 who were aware of their HIV-positive status were less likely to be on treatment than those 50–54 years old (aPR: 0.95, 95% CIs: 0.91–0.99, $p < 0.05$). In Rwanda, those aged 55–59 who were aware of their HIV-positive status were more likely to be on treatment than those 50–54 years old (aPR: 1.01, 95% CIs: 1.00–1.02, $p < 0.05$), while those 60–64 years of age were less likely to be on treatment than those 50–54 years old (aPR: 0.98, 95% CIs: 0.96–1.00, $p < 0.05$). Table 5 shows the third 90 VLS models for the 13 countries. One country showed higher achievement of the third 90 in an older age stratum. In Ethiopia, those aged 60–64 who were on treatment were more likely to have VLS compared to those 50–54 years old (aPR: 1.10, 95% CIs: 1.00–1.20, $p < 0.05$).

4 | DISCUSSION

Overall, OPLWH have made more progress towards achievement of 90-90-90 UNAIDS targets than PLWH aged 15–49. Progress by OPLWH towards 90-90-90 UNAIDS targets was noted in all 13 countries included in this analysis, which suggests they are well positioned to reach the 95-95-95 targets by 2025 as well. In two countries, Eswatini and Namibia, OPLWH have achieved all three 90-90-90 targets. In the other 11 countries, OPLWH have all achieved one or both of the second and third 90-90-90 targets. However, achievement of the first 90, that is awareness of HIV-positive status, continues to be a challenge [36, 37].

In the models we used, there was minimal variation demonstrated by age strata among OPLWH in the 13 countries. There was no variation in awareness by older age groups, three countries showed variation in treatment by older age groups—although not in a consistent direction, and one country showed higher VLS by an older age group. This lack of difference by age strata among OPLWH could indicate that those who have survived with HIV over the age of 50 are experienced with taking medications and older age does not diminish that fact.

Our findings are consistent with those from both a modelling study utilizing UNAIDS data and results from a systematic review and meta-analysis of 92 studies, which showed heterogeneity of 90-90-90 progress across countries, sex and age groups [5, 9]. Both studies, which did not specifically focus on OPLWH, noted more progress towards 90-90-90 targets among OPLWH compared with younger age groups, but neither examined progress among OPLWH in the various age strata within that group [5, 9]. Our findings among PLHIV aged 15–49 years were similar to other research as we also found that women were more likely to achieve the 90-90-90 targets than men; however, we noted different 90-90-90 progress among men and women among OPLWH in our study, with men making more progress to achieve the first and third 90 targets than women, while second 90 achievement was similar [5, 9].

A key finding highlighted by our study is the gap noted in the achievement of the first 90, that is awareness of HIV-positive status, among OPLWH [10, 37]. We found that

Table 2. Pooled 13 country descriptive clinical statistics among older persons living with HIV aged 50 and over

| | Males | | Females | | Total | |
|---|-------|---------------------|---------|---------------------|-------|---------------------|
| | N | % (95% CIs) | N | % (95% CIs) | N | % (95% CIs) |
| Diagnosis and treatment status (ARV-adj) | | | | | | |
| Unaware of HIV status | 316 | 22.46 (20.16–24.76) | 404 | 20.31 (18.72–21.89) | 720 | 21.25 (19.94–22.56) |
| Aware of HIV status and not on ART | 60 | 2.98 (2.36–3.60) | 94 | 2.49 (1.98–3.00) | 154 | 2.70 (2.30–3.11) |
| Aware of HIV status and on ART | 1535 | 74.56 (72.20–76.91) | 2247 | 77.20 (75.56–78.84) | 3782 | 76.05 (74.71–77.39) |
| ARVs detected | | | | | | |
| Yes | 1467 | 70.39 (67.99–72.79) | 2165 | 74.65 (72.92–76.38) | 3632 | 72.79 (71.34–74.23) |
| No | 437 | 29.61 (27.21–32.01) | 566 | 25.35 (23.62–27.08) | 1003 | 27.21 (25.77–28.66) |
| VLS | | | | | | |
| Yes | 1460 | 70.90 (68.51–73.29) | 2176 | 75.51 (73.74–77.27) | 3636 | 73.50 (72.02–74.97) |
| No | 450 | 29.10 (26.71–31.49) | 566 | 24.49 (22.73–26.26) | 1016 | 26.50 (25.03–27.98) |
| CD4 cell count per μ l | | | | | | |
| <100 | 50 | 3.19 (2.58–3.81) | 37 | 1.69 (1.13–2.24) | 87 | 2.36 (1.95–2.76) |
| 100–199 | 221 | 14.57 (12.89–16.25) | 161 | 7.89 (6.48–9.31) | 382 | 10.87 (9.77–11.97) |
| 200–349 | 473 | 29.09 (26.69–31.49) | 414 | 17.58 (15.79–19.37) | 887 | 22.71 (21.11–24.30) |
| 350–499 | 453 | 27.11 (24.88–29.34) | 566 | 26.97 (24.90–29.04) | 1019 | 27.03 (25.32–28.75) |
| \geq 500 | 500 | 26.04 (23.80–28.27) | 1215 | 45.88 (43.58–48.17) | 1715 | 37.04 (35.32–38.75) |
| Testing history | | | | | | |
| Never tested | 155 | 11.39 (9.49–13.29) | 243 | 13.69 (12.15–15.22) | 398 | 12.68 (11.67–13.70) |
| Tested in the past year | 547 | 27.83 (25.98–29.68) | 719 | 26.44 (24.75–28.13) | 1266 | 27.04 (25.74–28.34) |
| Tested more than 1 year ago | 1113 | 56.61 (54.22–59.01) | 1663 | 56.27 (54.39–58.14) | 2776 | 56.42 (54.98–57.86) |
| Don't know or missing | 96 | 4.17 (3.42–4.93) | 120 | 3.61 (2.85–4.37) | 216 | 3.85 (3.33–4.38) |
| Number of years since diagnosis | | | | | | |
| Less than 12 months | 97 | 6.96 (5.98–8.02) | 135 | 6.71 (5.78–7.64) | 232 | 6.82 (6.11–7.53) |
| 1 to less than 5 years | 453 | 32.32 (29.97–34.66) | 634 | 31.78 (29.84–33.71) | 1087 | 32.01 (30.44–33.58) |
| 5 years or more | 868 | 60.73 (58.30–63.15) | 1334 | 61.51 (59.59–63.43) | 2202 | 61.17 (59.6–62.75) |
| Antiretroviral regimen (among ARV detected) | | | | | | |
| First line (EVP, NVP and INSTI) | 1435 | 96.89 (96.38–97.40) | 2120 | 97.06 (96.30–97.83) | 3555 | 96.99 (96.49–97.49) |
| Second line (PI, LPV and ATV) | 29 | 3.07 (2.57–3.58) | 42 | 2.71 (1.95–3.47) | 71 | 2.86 (2.36–3.36) |
| Both | 2 | 0.04 (0.00–0.09) | 3 | 0.23 (0.22–0.23) | 5 | 0.15 (0.13–0.17) |
| Number of years since initiating ART | | | | | | |
| Less than 12 months | 125 | 8.78 (7.77–9.79) | 196 | 10.69 (9.25–12.12) | 321 | 9.87 (8.96–10.78) |
| 1 to less than 5 years | 466 | 35.43 (33.07–37.79) | 647 | 35.18 (33.15–37.22) | 1113 | 35.29 (33.66–36.91) |
| 5 years or more | 758 | 55.79 (53.45–58.13) | 1131 | 54.13 (52.11–56.16) | 1889 | 54.84 (53.28–56.41) |

Note: CD4 cell count does not include Kenya or Rwanda as CD4 testing was not conducted.
Abbreviations: ART, antiretroviral therapy; ARV, antiretroviral; VLS, viral load suppression; EVP, Emtricitabine/rilpivirine/tenofovir; NVP, Nevirapine; INSTI, Integrase strand transfer inhibitors; PI, protease inhibitor; LPV, Lopinavir; ATV, Atazanavir.
Definitions: Diagnosis and treatment status: Percent distribution of HIV-positive persons by HIV diagnosis and treatment status; ARVs detected: Percent distribution of HIV-positive persons by the presence of detectable ARVs; VLS: Among HIV-positive persons, percentage with viral load suppression (< 1000 copies/ml); CD4 cell count per μ l: Among HIV-positive persons, percentage with CD4 count within each range; Testing history: Percentage of persons who ever received HIV testing and received their test results; Number of years since diagnosis: Percent distribution of HIV-positive persons by time since diagnosis; Antiretroviral regimen (among ARV detected): Among those with detected ARVs, percent distribution on first line, second line or both regimens; Number of years since initiating ART: Among those self-reporting taking ARVs, percent distribution of time since initiating ART.

21.3% of all OPLWH were unaware of their HIV-positive status before the surveys, and more than half (54%) of these unaware OPLWH had never previously been tested. Existing research suggests that older adults have less knowledge and understanding of HIV infection than younger age groups and are, therefore, less likely to seek testing [37]. Providers often do not consider older adults to be at risk for HIV so there

is hesitation to discuss risk behaviours associated with HIV acquisition, such as inquiring into sexual activity and other risk behaviours, though older adults may have similar risks of HIV infection as younger adults [8, 10, 11, 38–40]. This provider bias combined with a lack of understanding of ongoing transmission risk for HIV infection in this population among both the providers and the older adults results in many missed

Table 3. Poisson regression models for awareness of HIV-positive status (first 90), Population-based HIV Impact Assessments, 13 countries, 2015–2019

| Country | Aged 50–54 | | | Aged 55–59 | | | Aged 60–64 | | | Aged 65+ | | |
|---------------|------------|------------------------|------------------|------------|---------------------|------------------|------------|------------------------|-------------------|----------|---------------------|------------------|
| | n | % (95% CI) | aPR ^a | n | % (95% CI) | aPR ^a | n | % (95% CI) | aPR ^a | n | % (95% CI) | aPR ^a |
| Malawi | 133 | 80.28 (73.57–86.99) | 1.00 | 91 | 82.32 (74.81–89.83) | 1.03 (0.87–1.22) | 59 | 85.78 (81.18–93.06) | 1.04 (0.87–1.25) | NA | NA | NA |
| Zambia | 175 | 82.80 (79.39–86.22) | 1.00 | 97 | 80.58 (76.53–84.62) | 0.93 (0.84–1.03) | NA | NA | NA | NA | NA | NA |
| Eswatini | 203 | 92.05 (88.45–95.65) | 1.00 | 140 | 92.77 (88.31–97.23) | 1.01 (0.95–1.08) | 111 | 91.68 (86.32–97.04) | 0.98 (0.91–1.07) | 84 | 90.61 (83.83–97.39) | 0.99 (0.89–1.11) |
| Tanzania | 107 | 69.95 (64.15–75.76) | 1.00 | 77 | 69.43 (60.30–78.55) | 0.96 (0.76–1.21) | 43 | 54.99 (41.33–68.66) | 0.83– (0.55–1.25) | 30 | 47.61 (35.47–59.76) | 0.73 (0.48–1.12) |
| Zimbabwe | 242 | 85.33 (80.98–89.69) | 1.00 | 195 | 81.74 (76.26–87.23) | 0.95 (0.86–1.05) | 121 | 82.32 (77.17–87.46) | 0.96 (0.87–1.06) | 92 | 75.91 (68.66–83.16) | 0.89 (0.76–1.04) |
| Uganda | 115 | 86.48 (82.72–90.24) | 1.00 | 68 | 79.75 (73.49–86.00) | 0.91 (0.74–1.13) | 55 | 90.02 (85.58–94.46) | 1.04 (0.88–1.23) | NA | NA | NA |
| Lesotho | 263 | 90.17 (87.22–93.11) | 1.00 | 226 | 87.76 (84.38–91.13) | 0.98 (0.92–1.04) | NA | NA | NA | NA | NA | NA |
| Cameroon | 55 | 70.03 (65.54–74.52) | 1.00 | 33 | 68.39 (53.86–82.92) | 0.96 (0.64–1.44) | 38 | 69.30 (62.00–76.60) | 0.98 (0.76–1.26) | NA | NA | NA |
| Namibia | 225 | 92.88 (89.51–96.24) | 1.00 | 150 | 95.07 (92.27–97.87) | 1.01 (0.95–1.07) | 90 | 96.85 (92.88–100.00) | 1.05 (0.97–1.13) | NA | NA | NA |
| Cote d'Ivoire | 27 | 70.02 (62.40–77.64) | 1.00 | 22 | 55.27 (38.82–71.72) | 0.86 (0.60–1.24) | 11 | 42.48 (28.64–56.32) | 0.61 (0.32–1.15) | NA | NA | NA |
| Ethiopia | 42 | 88.97 (84.62–93.32) | 1.00 | 15 | 87.26 (82.22–92.30) | 0.99 (0.78–1.26) | 18 | 83.72 (70.56–96.88) | 0.96 (0.70–1.33) | NA | NA | NA |
| Kenya | 134 | 87.64 (84.23–91.05) | 1.00 | 87 | 80.75 (77.00–84.50) | 0.91 (0.81–1.02) | 62 | 96.06 (95.43–96.68) | 1.07 (0.97–1.18) | NA | NA | NA |
| Rwanda | 88 | 85.10 (79.24–90.97) | 1.00 | 68 | 88.94 (84.24–93.63) | 1.06 (0.92–1.23) | 44 | 95.21 (89.95–100.00) | 1.12 (0.93–1.35) | NA | NA | NA |

Note: Upper age limits for individual eligibility varied by country: 59 years of age for Lesotho and Zambia, 64 years of age for Cameroon, Cote d'Ivoire, Ethiopia, Kenya, Malawi, Namibia, Rwanda and Uganda, and no upper age limit in Eswatini, Tanzania and Zimbabwe.

^aAdjusted for sex, residence, employed, wealth quintile, education, marital status and partner HIV status-self-reported.

Table 4. Poisson regression models for antiretroviral therapy use among those aware of HIV-positive status (second 90), Population-based HIV Impact Assessments, 13 countries, 2015–2019

| Country | Aged 50–54 | | | Aged 55–59 | | | Aged 60–64 | | | Aged 65+ | | |
|---------------|------------|------------------------|------------------|------------|------------------------|-------------------|------------|------------------------|----------------------|----------|----------------------|------------------|
| | n | % (95% CI) | aPR ^a | n | % (95% CI) | aPR ^a | N | % (95% CI) | aPR ^a | n | % (95% CI) | aPR ^a |
| Malawi | 126 | 96.29 (94.56–98.01) | 1.00 | 85 | 94.47 (93.34–95.59) | 1.01 (0.96–1.07) | 57 | 94.5 (90.03–98.97) | 0.99 (0.94–1.04) | NA | NA | NA |
| Zambia | 164 | 94.13 (91.05–97.21) | 1.00 | 92 | 95.67 (93.06–98.28) | 1.03 (0.95–1.11) | NA | NA | NA | NA | NA | NA |
| Eswatini | 189 | 91.85 (88.13–95.57) | 1.00 | 131 | 93.31 (89.35–97.26) | 1.01 (0.94–1.08) | 109 | 98.79 (97.51–100.00) | 1.06 (1.01–1.11)* | 82 | 98.04 (95.31–100.00) | 1.06 (1.00–1.11) |
| Tanzania | 103 | 96.76 (95.83–97.69) | 1.00 | 75 | 99.09 (97.58–100.00) | 1.02 (0.98–1.05) | 43 | 100.00 (100.00–100.00) | 1.01 (0.96–1.05) | 27 | 91.77 (77.97–100.00) | 0.94 (0.66–1.32) |
| Zimbabwe | 235 | 97.63 (95.90–99.35) | 1.00 | 189 | 97.10 (95.42–98.77) | 1.00 (0.96–1.03) | 113 | 94.11 (90.28–97.95) | 0.98 (0.93–1.03) | 90 | 98.33 (95.99–100.00) | 1.02 (0.97–1.07) |
| Uganda | 105 | 93.62 (90.34–96.90) | 1.00 | 66 | 96.35 (95.73–96.98) | 1.03 (0.94–1.12) | 52 | 94.04 (92.59–95.49) | 1.01 (0.93–1.11) | NA | NA | NA |
| Lesotho | 253 | 95.43 (93.32–97.53) | 1.00 | 222 | 97.94 (96.54–99.34) | 1.01 (0.98–1.05) | NA | NA | NA | NA | NA | NA |
| Cameroon | 54 | 99.95 (99.83–100.00) | 1.00 | 31 | 92.95 (91.73–94.17) | 0.95 (0.89–1.02) | 36 | 95.48 (94.55–96.41) | 0.95 (0.91–0.99)* | NA | NA | NA |
| Namibia | 215 | 95.83 (92.99–98.67) | 1.00 | 147 | 98.2 (96.43–99.96) | 1.01 (0.97–1.05) | 89 | 98.90 (96.71–100.00) | 1.02 (0.97–1.06) | NA | NA | NA |
| Cote d'Ivoire | 24 | 95.39 (94.04–96.75) | 1.00 | 20 | 96.45 (94.10–100.00) | 1.01 (0.96–1.05) | 11 | 100.00 (100.00–100.00) | 1.11 (0.37–3.40) | NA | NA | NA |
| Ethiopia | 41 | 97.39 (96.76–98.03) | 1.00 | 15 | 100.00 (100.00–100.00) | 1.04 (0.94–1.16) | 17 | 91.13 (88.96–93.3) | 0.91 (0.74–1.12) | NA | NA | NA |
| Kenya | 129 | 96.67 (93.65–99.69) | 1.00 | 85 | 97.83 (94.66–100.00) | 1.02 (0.89–1.16) | 62 | 100.00 (100.00–100.00) | 1.04 (0.95–1.14) | NA | NA | NA |
| Rwanda | 87 | 99.21 (99.10–99.31) | 1.00 | 68 | 100.00 (100.00–100.00) | 1.01 (1.00–1.02)* | 43 | 97.23 (96.81–97.65) | 0.98 (0.96–1.00)* | NA | NA | NA |

^aAdjusted for sex, residence, employed, wealth quintile, education, marital status, partner HIV status-self-reported and the number of years since diagnosis.
 **p* < 0.05.

Table 5. Poisson regression models for viral load suppression among those on antiretroviral therapy (third 90), Population-based HIV Impact Assessments, 13 countries, 2015–2019

| Country | Aged 50–54 | | | Aged 55–59 | | | Aged 60–64 | | | Aged 65+ | | |
|---------------|------------|------------------------|------------------|------------|---------------------|------------------|------------|------------------------|----------------------|----------|---------------------|------------------|
| | n | % (95% CI) | aPR ^a | n | % (95% CI) | aPR ^a | n | % (95% CI) | aPR ^a | n | % (95% CI) | aPR ^a |
| Malawi | 119 | 93.43 (90.02–96.84) | 1.00 | 79 | 91.71 (86.25–97.18) | 1.01 (0.89–1.15) | 52 | 93.78 (90.32–97.25) | 0.99 (0.88–1.12) | NA | NA | NA |
| Zambia | 154 | 93.49 (90.61–96.37) | 1.00 | 91 | 99.39 (99.29–99.48) | 1.07 (0.99–1.15) | NA | NA | NA | NA | NA | NA |
| Eswatini | 182 | 96.81 (94.61–99.02) | 1.00 | 125 | 95.86 (92.55–99.18) | 1.01 (0.95–1.07) | 107 | 98.51 (96.43–100.00) | 1.01 (0.98–1.05) | 77 | 94.3 (89.04–99.55) | 0.97 (0.89–1.05) |
| Tanzania | 91 | 91.78 (89.08–94.49) | 1.00 | 70 | 90.58 (81.37–99.78) | 1.01 (0.90–1.15) | 38 | 87.68 (81.39–93.98) | 0.90 (0.72–1.11) | 25 | 90.04 (84.80–95.28) | 1.06 (0.97–1.16) |
| Zimbabwe | 215 | 90.89 (87.67–94.11) | 1.00 | 177 | 93.96 (90.87–97.05) | 1.05 (0.98–1.12) | 106 | 93.72 (88.1–99.35) | 1.05 (0.96–1.14) | 81 | 88.03 (81.05–95.01) | 1.01 (0.89–1.14) |
| Uganda | 93 | 88.63 (84.27–93.00) | 1.00 | 58 | 86.75 (81.94–91.56) | 1.06 (0.86–1.31) | 39 | 77.02 (66.61–87.42) | 0.94 (0.68–1.29) | NA | NA | NA |
| Lesotho | 233 | 91.97 (88.96–94.99) | 1.00 | 211 | 95.03 (92.98–97.09) | 1.01 (0.96–1.07) | NA | NA | NA | NA | NA | NA |
| Cameroon | 46 | 86.78 (78.44–95.11) | 1.00 | 29 | 91.03 (89.34–92.71) | 1.22 (0.69–2.18) | 33 | 92.02 (84.51–99.54) | 1.07 (0.82–1.39) | NA | NA | NA |
| Namibia | 197 | 93.29 (89.75–96.83) | 1.00 | 137 | 93.92 (91.34–96.51) | 0.99 (0.94–1.05) | 85 | 96.73 (93.47–100.00) | 1.03 (0.96–1.12) | NA | NA | NA |
| Cote d'Ivoire | 23 | 94.75 (92.55–96.94) | 1.00 | 18 | 95.47 (95.12–95.81) | 1.09 (0.49–2.45) | 9 | 74.69 (55.14–94.24) | 0.94 (0.72–1.23) | NA | NA | NA |
| Ethiopia | 38 | 92.56 (90.69–94.43) | 1.00 | 14 | 98.07 (97.15–98.98) | 1.01 (0.87–1.17) | 15 | 86.20 (73.10–99.29) | 1.10 (1.00–1.20)* | NA | NA | NA |
| Kenya | 120 | 93.01 (90.07–95.96) | 1.00 | 80 | 94.61 (93.24–95.99) | 1.02 (0.93–1.12) | 60 | 97.00 (96.50–97.49) | 1.03 (0.92–1.14) | NA | NA | NA |
| Rwanda | 81 | 92.52 (88.95–96.09) | 1.00 | 63 | 91.37 (85.78–96.96) | 1.01 (0.90–1.14) | 38 | 87.36 (79.59–95.13) | 0.98 (0.87–1.11) | NA | NA | NA |

^aAdjusted for sex, residence, employed, wealth quintile, education, marital status, partner HIV status-self-reported and the number of years since initiating ART.

**p* < 0.05.

opportunities for HIV testing, access to HIV prevention and initiation and retention in treatment services. Country HIV programmes could benefit from additional strategies to raise awareness among healthcare providers and increase health communication campaigns about testing and existing prevention interventions (such as knowledge of partner HIV status and the use of condoms, PrEP or treatment as prevention [U = U] for discordant couples) targeting older populations in SSA [41, 42].

Many OPLWH will wait to test for HIV until symptomatic which results in a delay in diagnosis of HIV and initiation of ART, resulting in poorer health outcomes [8, 38, 43]. In addition, age-disparate relationships are associated with higher HIV acquisition among adolescent girls and young women [44]. As such, more effective case-finding among older men may also have positive consequences on reducing onward transmission. Innovative testing strategies to reach older adults, such as establishing tailored testing initiatives for this age group, use of self-testing and delivery of testing through community-based services, have been shown to be useful to increase more frequent and earlier testing [5, 45]. In addition, OPLWH are managing other chronic health conditions and are at higher risk of developing age-associated non-communicable diseases, such as cardiovascular disease, neurocognitive disorders and frailty [46]. Older adults may be more likely to seek medical care for reasons other than HIV but provider-initiated counselling and testing may be overlooked for this population because they are thought not to be at risk [47]. These findings suggest the need for further sensitization and training for health providers to elicit sexual and history of risk behaviours among older patients and to offer them HIV testing as a comprehensive strategy to identify all HIV-positive individuals and combining with non-HIV care management, as part of routine provider-initiated counselling and testing [48, 49].

The finding that OPLWH were more likely to be aware of their HIV-positive status than younger PLWH may be due to survivor bias; those who remained unaware of their HIV-positive status longer were more likely to have died compared to those who became aware sooner, that is at a young age. Studies have shown that age is associated with adherence to ART and achievement of VLS [50]. One study that assessed mortality in SSA among HIV-positive individuals on ART found that sex differences in all-cause mortality and loss-to-follow-up noted in younger people were also present among those ages 50–59, with older women on ART at greater risk of death as they age compared with men [51]. Additionally, there is a potential cohort effect for mortality among the OPLWH who have survived to this point compared with younger PLWH [38, 52]. There was a global mortality peak from AIDS-related deaths in 2005/2006, at a time when our OPLWH cohort was aged 35–50, and since 2010, there has been a 50% reduction in AIDS-related deaths in Eastern and Southern Africa [53]. Additionally, PHIA surveys in many countries were conducted before test and treat protocols and treatment with dolutegravir was fully rolled out, potentially contributing to some countries not achieving the third 90 yet [54–56].

The study has several strengths. One key feature is that the PHIA surveys provided nationally representative data for all 13 countries, including HIV-related biomarkers. Because the

PHIA surveys are collected in the household, they capture information on those who may not be engaged in care and accessing health services, including older people who may be living with HIV and have yet to access treatment. The findings highlight the importance of expanding the age limits of all HIV surveys and surveillance efforts, to track progress among the growing population of OPLWH. The study also has some limitations. The surveys were all cross-sectional in nature and only represent one time point. However, repeat PHIA surveys have been done in several countries, which will permit the assessment of trends among OPLWH over time in the future. Additionally, the upper age ranges varied across PHIA surveys: two countries did not have data for ages above 59, and eight countries did not have data for ages 65 and older. We examined results of 90–90–90 achievement by upper age limit in each country and did not observe any differences in 90–90–90 achievement between countries based on upper age limit; successful achievement was distributed across all countries.

5 | CONCLUSIONS

In conclusion, finding gaps in the knowledge of HIV-positive status among OPLWH in several African countries highlights the importance of focused HIV awareness and the need to expand HIV testing efforts for older adults, as it impacts the care and treatment cascade and reduces longevity and quality of life. At the same time, HIV programmes and providers could use these findings to support improved HIV counselling, education and screening of older adults on risk behaviours and offer them HIV prevention, testing and treatment services.

AUTHORS' AFFILIATIONS

¹ICAP at Columbia University, New York City, New York, USA; ²Department of Epidemiology, Mailman School of Public Health, Columbia University, New York City, New York, USA; ³Malawi Ministry of Health, Lilongwe, Malawi; ⁴US Centers for Disease Control and Prevention (CDC), Lilongwe, Malawi; ⁵CDC, Mbabane, Eswatini; ⁶CDC, Dar es Salaam, Tanzania; ⁷Ministry of Health, Community Development, Gender, Elderly and Children through The National AIDS Control Program (NACP), Dodoma, Tanzania; ⁸CDC, Lusaka, Zambia; ⁹CDC, Windhoek, Namibia; ¹⁰Ministry of Health and Social Services, Windhoek, Namibia; ¹¹CDC, Nairobi, Kenya; ¹²CDC, Maseru, Lesotho; ¹³CDC, Kampala, Uganda; ¹⁴CDC, Harare, Zimbabwe; ¹⁵Zimbabwe Ministry of Health and Child Care, Harare, Zimbabwe; ¹⁶CDC, Yaounde, Cameroon; ¹⁷Cameroon Ministry of Public Health, Yaounde, Cameroon; ¹⁸Ethiopia Public Health Institute, Addis Ababa, Ethiopia; ¹⁹CDC, Addis Ababa, Ethiopia; ²⁰Uganda Ministry of Health, Kampala, Uganda; ²¹CDC, Abidjan, Cote d'Ivoire; ²²CDC, Kigali, Rwanda; ²³CDC, Atlanta, Georgia, USA

COMPETING INTERESTS

None to declare for any authors.

AUTHORS' CONTRIBUTIONS

All authors have read and approved the manuscript. SMF conceptualized, drafted and edited the manuscript. CW and RB conceptualized and conducted analyses and edited the manuscript. AL, SD, DH, ANK and TGH conceptualized and edited the manuscript. RN, NW, ML, MA, MJ, NK, IP, NM, SSN, AOA, EWN, FMA, SL, JW, PC, OM, BKM, PN, DA, AK, SB, FN, GM, CBN, JDS, EKD, LED, RM-S, A-CB, YG, FE, TN, LT, RFK, WK, JM, SB, EK, GR, AA, CW, SB, KS, HKP, KB and ACV reviewed and edited the manuscript. WME and JJ conceptualized, reviewed and edited the manuscript.

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DISCLAIMER

The findings and conclusions in this manuscript are those of the authors and do not necessarily represent the official position of the funding agencies.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available upon request from the PHIA project website: <https://phia-data.icap.columbia.edu/>.

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