



# Progress of UNAIDS 90-90-90 targets in a district in KwaZulu-Natal, South Africa, with high HIV burden, in the HIPSS study: a household-based complex multilevel community survey

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## Summary

**Background** With the goal of eliminating new HIV infections, UNAIDS set the ambitious 90-90-90 targets to be achieved by 2020. We assessed whether these targets are being met among participants of the HIV Incidence Provincial Surveillance System (HIPSS) in a high-burden district of South Africa.

**Methods** We used data from a HIPSS household-based, cross-sectional survey of HIV prevalence and incidence done in the uMgungundlovu district, KwaZulu-Natal, in 2014 and 2015. In randomly selected enumeration areas, 50 households were drawn systematically along a serpentine pattern from a random start point. One eligible individual in each household was asked to provide blood for HIV testing and to complete a questionnaire. If a household refused to participate, the house next to it was approached. Eligible participants were aged 15–49 years, lived in the household, were not planning to move away, and spoke English or Zulu. Viral load was measured in samples positive for HIV. We also assessed participants' HIV linkage to care and treatment. Data were population weighted to allow for multilevel sampling and non-response.

**Findings** 9812 participants were enrolled, 3547 men (36%) and 6265 women (64%). Overall, 504 of 1014 men (estimate 52%, 95% CI 47–56) and 1833 of 2955 women (65%, 62–67) who were HIV positive knew their HIV status. Of those who knew, 344 of 522 men (69%, 63–75) and 1254 of 1845 women (70%, 68–73) were taking ART. Among recipients of ART, 294 of 341 men (85%, 80–90) and 1117 of 1249 women (90%, 87–92) had viral loads less than 1000 copies per mL. Among all HIV-positive participants, 427 of 1014 men (44%, 39–49) and 1680 of 2955 women (58%, 55–61) had viral loads lower than 1000 copies per mL.

**Interpretation** No UNAIDS 90-90-90 targets had been met in our study population. Major campaigns are needed to increase HIV testing, especially among men, and to ensure all HIV-positive patients are taking ART.

**Funding** Centers for Disease Control and Prevention and the US Presidents Emergency Plan for AIDS Relief (PEPFAR).

## Introduction

Antiretroviral therapy (ART) prevents HIV transmission,<sup>1</sup> and in the HPTN052 study,<sup>2</sup> provided 96% protection against transmission when the HIV-positive partner in a couple was treated. In another study of 767 HIV-serodiscordant couples who did not use condoms, no HIV transmissions occurred when the HIV-positive person was taking ART and had achieved viral suppression.<sup>3</sup> Undetectable HIV RNA reflects successful treatment, improved individual health, and correlates with reduced HIV transmission.<sup>4</sup> Giving more HIV-positive people ART is expected to reduce HIV incidence at a population level. In an area of KwaZulu-Natal, South Africa, every 1% increase in coverage of ART has reduced HIV incidence by 1·1%.<sup>5</sup>

Aiming to end the AIDS epidemic worldwide, UNAIDS has set ambitious targets of having 90% of people living with HIV knowing their HIV status, 90% of people diagnosed as having HIV receiving sustained ART, and 90% of people receiving ART having viral suppression by 2020.<sup>6</sup> When these targets are met, 73% of all HIV-positive

people would have viral suppression, which, according to modelling, would end the AIDS epidemic by 2030.<sup>6</sup> Delivery of medical care to HIV-positive people requires a sequence of diagnostic tests, treatment with ART, and monitoring of viral load: the HIV linkage to care and treatment cascade.<sup>7,8</sup>

In South Africa, the HIV epidemic has substantial geographical variation, with KwaZulu-Natal having the highest burden and a provincial HIV prevalence in pregnant women of 40% (95% CI 38–42). By contrast, in the Northern Cape, the province with the lowest burden, antenatal HIV prevalence was less than half of that in KwaZulu-Natal (18%, 95% CI 15–20). In addition to provincial variation, there is much heterogeneity at district level. Within KwaZulu-Natal, antenatal HIV prevalence varies from 46% (the highest nationally) in iLembe to 33% in Amajuba, although in all 12 districts in KwaZulu-Natal, HIV prevalence exceeds 30%.<sup>9</sup>

Despite 1·8 million people taking ART in South Africa, the high number of people needing treatment means that coverage is low (52% in 2011).<sup>10</sup> South Africa expanded

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### Research in context

#### Evidence before this study

In 2014, UNAIDS proposed their 90-90-90 HIV testing and treatment targets for 2020. We searched PubMed with the search terms “90-90-90”, “HIV”, and “Africa” for all English-language papers reporting on these targets published from Jan 1, 2014, to May 31, 2016. Measuring the progress towards achieving these targets, however, is difficult. Most available data are not based on population-based random surveys and, therefore, do not provide unbiased population-level estimates. Rather, most information is derived from model-based estimates, self-reported HIV status, or data collected routinely in clinics.

#### Added value of this study

The first target, knowledge of HIV status, can only be measured in a population-based study and not with clinic-based data. The last target, viral suppression, cannot be based solely on patients attending ART clinics because it excludes patients who start

ART but in whom viral load has not been assessed. Our study overcame both these issues. We used data from a multilevel community survey to measure directly population-level knowledge of HIV status, use of ART, and viral suppression (based on self-reports and laboratory testing) to assess progress towards achieving the 90-90-90 targets in an area with a high HIV burden. The UNAIDS 90-90-90 targets were not met in our study population, mainly owing to lack of knowledge of HIV status, especially among men. The target best achieved was viral suppression by ART.

#### Implications of all the available evidence

It is unlikely that the UNAIDS 90-90-90 targets will be met in most high-burden countries and areas by 2020. Some isolated countries (eg, Botswana) or communities might reach these targets, but other countries, such as Kenya, are far from doing so. Major campaigns are needed to increase the prevalence of HIV testing, especially among men.

access to ART by changing the eligibility criteria from a CD4 count less than 200 cells per  $\mu\text{L}$  to a count less than 350 cells per  $\mu\text{L}$  in 2013,<sup>11</sup> and again in 2015, after this study had started, to less than 500 cells per  $\mu\text{L}$ .<sup>12</sup> We assessed the HIV linkage to care and treatment cascade among participants enrolled in the HIV Incidence Provincial Surveillance System (HIPSS), a multilevel community-based survey, in KwaZulu-Natal, South Africa. We aimed to identify the points in the cascade where patients are lost to care, preventing them from achieving continuous HIV treatment and viral suppression.

## Methods

### Study design and population

The design of HIPSS has been described elsewhere.<sup>13</sup> Briefly, a three-stage sampling design was used to randomly select a household-based representative sample of 10000 individuals in two cross-sectional surveys (appendix). In the first stage, 212 enumeration areas used for the national census were drawn randomly. In the second stage, from each enumeration area 50 households were drawn systematically along a serpentine pattern from a random start point. These households were approached, and if a household refused, the house next to it was approached instead. In the third stage, one member of each selected household was selected at random. For this analysis, we used data from a HIPSS cross-sectional survey done from June 11, 2014, to June 22, 2015, in Vulindlela and Greater Edendale in uMgungundlovu District, central KwaZulu-Natal, where the HIV prevalence among pregnant women was 42% (95% CI 35–51)—one of six districts in South Africa with antenatal HIV prevalence greater than 40%.<sup>9</sup> The estimated population in the study area was 117976 men and 126723 women; 48% of the population was male.

Eligible participants were men and women aged 15–49 years residing in the selected households who were willing to participate and undergo study procedures, and could provide written informed consent in either English or Zulu (or parental consent with assent if participants were <18 years). We excluded individuals who did not have the mental capacity to provide consent or who were planning to relocate within 12 months.

Selected individuals were interviewed by fieldworkers with use of a standardised questionnaire with closed-ended questions about demographic and socioeconomic characteristics, behavioural and medical information, HIV status, sexual risk behaviour, and access to health care. Women were also asked about childbearing history and access to prevention of mother-to-child transmission services, and men were additionally asked about circumcision status.

Participants provided plasma, urine, and genital swab samples to allow testing for HIV, sexually transmitted infections, and pregnancy. HIV testing was done with fourth generation EIAs,<sup>14</sup> with HIV antibodies and antigens measured by the Biomérieux Vironostika Uniform II Antigen/Antibody Microelisa system (BioMérieux, Marcy l’Etoile, France) and HIV 1/2 Combi Roche Elecsys (Roche Diagnostics, Penzberg, Germany). Positive samples were confirmed with an HIV-1 western blot assay (Bio-Rad Laboratories, Redmond, WA, USA). Individual HIV-1 RNA viral load measurements were tested with Roche COBAS Ampliprep/ COBAS TaqMan HIV-1 version 2.0 assay (TaqMan, Roche Diagnostics, Mannheim, Germany). In HIV-positive participants, CD4 cell counts were done with flow cytometry (BD FACSCalibur, BD Biosciences, San Jose, CA, USA) and viral load was measured with the COBAS AmpliPrep/COBAS TaqMan HIV-1 version 2.0

See Online for appendix

assay. Testing for presence of ART (nevirapine, efavirenz, lamivudine, emtricitabine, zidovudine, lopinavir, tenofovir) was done by high-performance liquid chromatography coupled to tandem mass spectrometry in HIV-positive participants who had high viral loads (>10 000 copies per mL) but who reported taking ART or in individuals who had undetectable viral loads but reported not taking ART.

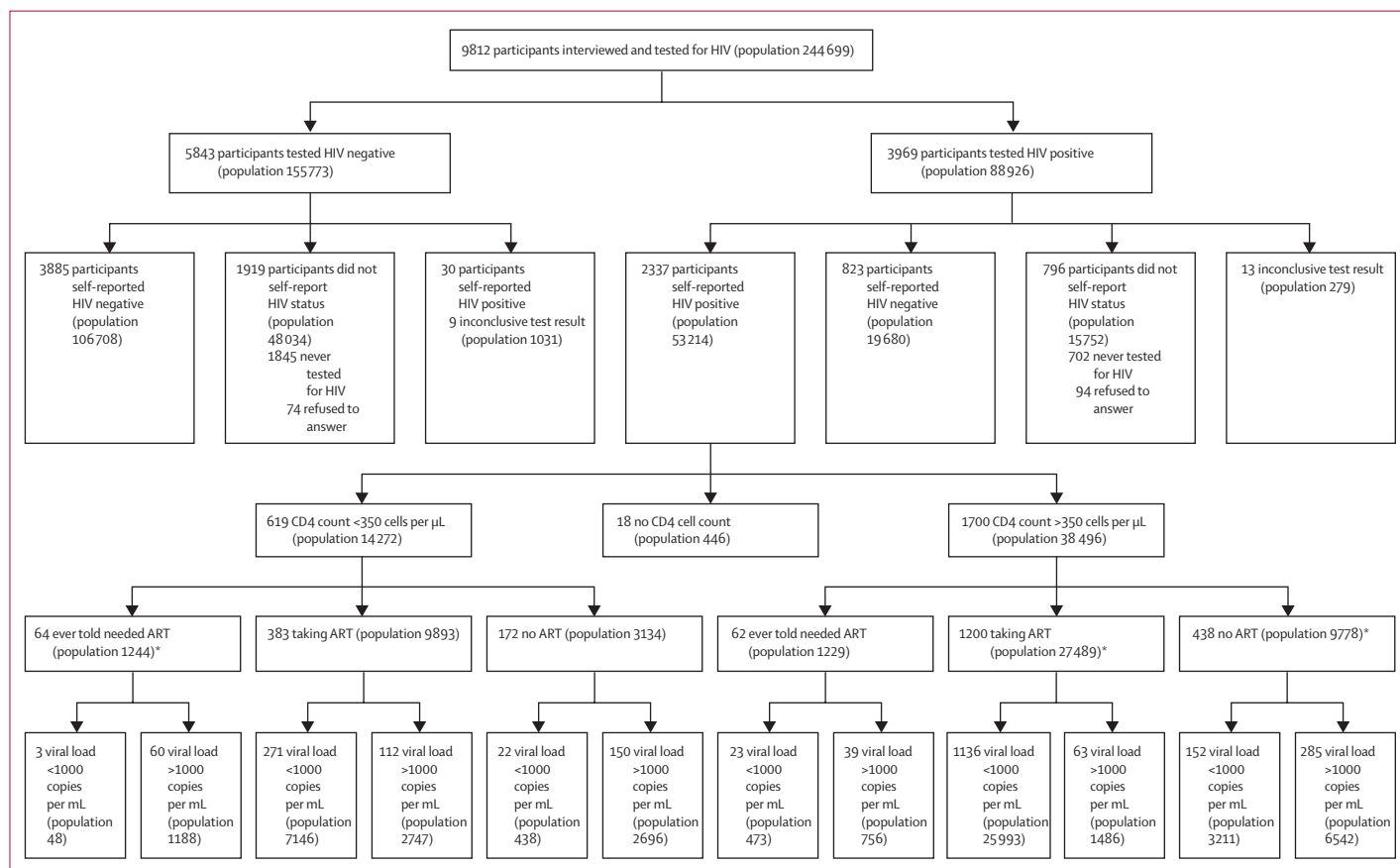
Ethics approval for HIPSS was provided by the University of KwaZulu-Natal biomedical research ethics committee (BF269/13) on May 13, 2014, and the US Centers for Disease Control and Prevention in collaboration with the Department of Health, Province of KwaZulu-Natal (HRKM 08/14). Participants gave written informed consent before enrolment.

### Statistical analysis

The sample for this study consisted of all participants enrolled in the HIPSS survey who provided peripheral blood samples for HIV testing and completed interview questions. The elements of the UNAIDS 90-90-90 treatment cascade were assessed in the following ways: the numerator for HIV status was the number of participants who had positive HIV tests and self-reported in the survey that they were HIV positive during the

interview, and the denominator was the number of participants who tested HIV positive in the survey; for receipt of sustained ART, the numerator was the number of participants who self-reported using ART in the interview and the denominator was the number of participants with laboratory confirmed HIV and who reported knowing they were HIV positive in the interview; for viral suppression, the numerator was the number of participants who self-reported using ART in the interview and had laboratory confirmed HIV RNA viral loads less than 1000 copies per mL, and the denominator was the number of participants who self-reported using ART. For receipt of sustained ART, we also did an analysis in which participants with laboratory confirmed presence of ART were included in the numerator. All participants who reported using ART were assumed to be retained in the cascade of care. Participants were classified as being linked to care if they reported receiving at least one of home-based care, a CD4 cell count, viral-load testing, and ART or treatment of opportunistic infections. We defined HIV-positive participants as those who tested positive in samples provided for this study.

To account for the complex multilevel sampling design, weighted proportions and SEs were analysed with SAS



**Figure 1: HIV status by laboratory testing, knowledge of HIV status, CD4 cell counts, ART status, and viral load suppression status**

Calculations were weighted; due to rounding the sum of some population numbers do not equal the total on the previous level. ART=antiretroviral therapy. \*One viral load missing.

(version 9.4) survey procedures (appendix). Weights took into account the probability of selecting the enumeration area, the household in the enumeration area, and the individual in the household, then were adjusted for non-response and benchmarked to the size of the population in the study area. For comparisons of weighted proportions, we calculated p values with the Rao-Scott  $\chi^2$  statistic, a design-adjusted version of the Pearson  $\chi^2$  statistic, using a

design correction based on the design effects of the proportions, which involved differences between observed and expected frequencies.<sup>15,16</sup> Estimates used a weighted likelihood function, weighted first derivatives, and the Newton-Raphson algorithm to find the coefficient estimates that maximised the weighted pseudolikelihood. We used the Taylor series method to estimate SEs of proportions and design-based CIs and test statistics. Descriptive statistics, such as population-weighted percentages, were weighted and are cited with 95% CIs. Unweighted counts are also presented.<sup>17</sup> Multivariate logistic regression was done to investigate factors associated with meeting each of the steps of the cascade.

**Role of the funding source**

The funders of the study played a role in the study design, data interpretation and writing of the report, but not in data collection or data analysis. The corresponding author had full access to all the data in the study and had final responsibility for the decision to submit for publication.

**Results**

Of 14 618 households approached for the HIPSS survey, 11 289 agreed to participate. 10 389 households (92%) had eligible participants, 577 (6%) of whom refused to participate. Thus, 9812 participants were enrolled in HIPSS and tested for HIV (figure 1), of whom 3547 (36%) were men and 6265 (64%) were women (table 1).

3969 of 9812 people overall were confirmed to be HIV positive (36%, 95% CI 35–38). The population-weighted HIV prevalence for men was 28% (95% CI 26–30, 1014 of 3547) and for women was 44% (42–46, 2955 of 6265,  $p < 0.0001$ ). Thus, we estimate that 33 045 HIV-positive men and 55 881 HIV-positive women aged 15–49 years were living in the overall study area. 31% of men (95% CI 29–33, 1221 of 3547) and 18% of women (16–20, 1326 of 6265) self-reported never having been tested for HIV. 52% of men (49–54, 1719 of 3547) and 52% of women (50–54, 2989 of 6265) reported being HIV negative. The remainder of participants (85 women and 105 men) refused to disclose HIV status to data collectors.

	Women (n=6265)	Men (n=3547)
<b>Marital status</b>		
Married or living together	857 (14%)	241 (8%)
Single	5408 (86%)	3306 (92%)
<b>Age group (years)</b>		
15–19	958 (18%)	658 (20%)
20–24	1266 (20%)	814 (21%)
25–29	1087 (18%)	602 (18%)
30–34	833 (14%)	461 (14%)
35–39	760 (12%)	405 (12%)
40–44	660 (10%)	320 (9%)
45–49	701 (9%)	287 (7%)
<b>Education</b>		
No schooling or before primary	265 (3%)	153 (3%)
Primary (grade 1–7)	375 (6%)	232 (7%)
Incomplete secondary (grade 8–11 or NQF level 3)	2674 (45%)	1547 (47%)
Completed secondary (grade 12 or NQF 4)	2603 (41%)	1406 (38%)
Tertiary (diploma/degree)	345 (5%)	207 (5%)
No response	3 (<0.5%)	2 (<0.6%)
African origin	6257 (>99%)	3545 (>99%)
Ever diagnosed with an STI	318 (6%)	231 (8%)
Ever had sex	5447 (86%)	2855 (81%)
Away from home for >1 month in the past 12 months	623 (10%)	398 (11%)
Ever been pregnant	4391 (71%)	NA

NQF=National Qualifications Framework. STI=sexually transmitted infection. NA=not applicable.

**Table 1: Baseline characteristics of enrolled participants**

	Men			Women			All		
	Number	Population	Proportion (95% CI)	Number	Population	Proportion (95% CI)	Number	Population	Proportion (95% CI)
Received nutritional support	173	6440	37% (29–44)	598	13 247	36% (31–41)	771	19 687	36% (31–41)
Had a treatment buddy	123	4116	23% (16–31)	422	7764	21% (18–25)	545	11 880	22% (18–26)
Home-based care	47	2109	12% (6–18)	182	3504	10% (7–12)	229	5613	10% (8–13)
Had a CD4 cell count	453	15 918	90% (87–93)	1679	33 830	93% (91–94)	2132	49 748	92% (90–94)
Received a viral-load test	380	13 402	76% (71–81)	1409	28 171	77% (74–81)	1789	41 573	77% (74–80)
Treatment of opportunistic infections	155	5326	30% (25–36)	485	11 007	30% (27–34)	640	16 333	30% (27–34)
Linked to care*	488	16 806	95% (93–97)	1762	35 065	96% (95–97)	2250	51 870	96% (95–97)

\*Self-reported home-based care, CD4 cell count, viral-load test, or treatment of opportunistic infection

**Table 2: Numbers of participants self-reported to be HIV positive who were linked to care**

2367 of 9748 participants (22%, 95% CI 21–24) self-reported that they were HIV positive, making the population-weighted prevalence 15% for men (13–17, 522 of 3529) and 29% for women (27–31, 1845 of 6219;  $p < 0.0001$ ). The proportions of participants accurately self-reporting their status as HIV positive in the interviews were 52% of men (47–56, 504 of 1014) and 65% of women (62–67, 1833 of 2955;  $p < 0.0001$ ). Among the 1014 HIV-positive men, 260 (23%, 19–26) self-reported to have never been tested and 205 (22%, 19–25) self-reported to have tested HIV negative in their latest HIV test (median time since latest test before survey 19 months, IQR 9–39). Among the 2955 HIV-positive women, 442 (11%, 9–13) self-reported to have never been tested and 618 (22%, 20–25) self-reported to have tested HIV negative in their latest HIV test (median time since testing 13 months, IQR 5–27). The remainder of participants with confirmed HIV-positive status (45 men and 62 women) refused to disclose HIV status to data collectors.

Of 4930 women who had ever been tested for HIV, 3918 (79%, 95% CI 78–81) had ever been pregnant, and among 1326 who had never been tested, 473 (32%, 28–36) had ever been pregnant ( $p < 0.0001$ ). 38% of HIV positive women (35–41, 672 of 1845) also reported receiving an HIV test at an antenatal visit. If these women are removed from the analysis, 20% of women (18–23, 1326 of 5593) had never been tested for HIV. Among women who had ever or never been pregnant, 8% (7–10, 3473 of 4391) and 42% (38–46, 853 of 1865), respectively, had never been tested for HIV.

Among participants who knew their HIV-positive status, almost all were linked to care (table 2, figure 2, appendix). The services accessed by most participants were CD4 cell counts and viral load testing (table 2).

Only 69% of men (95% CI 63–75, 344 of 522) and 70% of women (68–73, 1254 of 1845) who knew they were HIV positive were taking ART ( $p = 0.71$ ) and, respectively, among these only 5% (3–7, 32 of 522) and 5% (4–6, 97 of 1845) reported being told by a nurse or doctor that they needed ART but were not currently receiving treatment. Of all HIV-positive participants, irrespective of CD4 cell count or knowledge of HIV status, 1592 of 3969 (42%, 95% CI 40–45) reported taking ART. Among those with confirmed HIV-positive status, 341 of 1014 men (37%, 32–41) and 1251 of 2955 women (46%, 43–48) were taking ART ( $p = 0.0004$ ). When laboratory results for the presence of ART were included, the percentage of HIV-positive participants receiving ART remained similar (36% of men, 31–40, 331 of 1014, and 46% of women, 43–48, 1251 of 2955;  $p < 0.0001$ ).

Considering CD4-cell-count thresholds for starting ART, 74% of men (95% CI 66–82, 144 of 215) and 65% of women (59–71, 239 of 404) who had CD4 counts less than 350 cells per  $\mu\text{L}$  reported taking ART. Similarly, 75% of men (69–81, 226 of 330) and 66% of women (62–71, 506 of 802) who had CD4 counts less than 500 cells per  $\mu\text{L}$  reported taking ART.

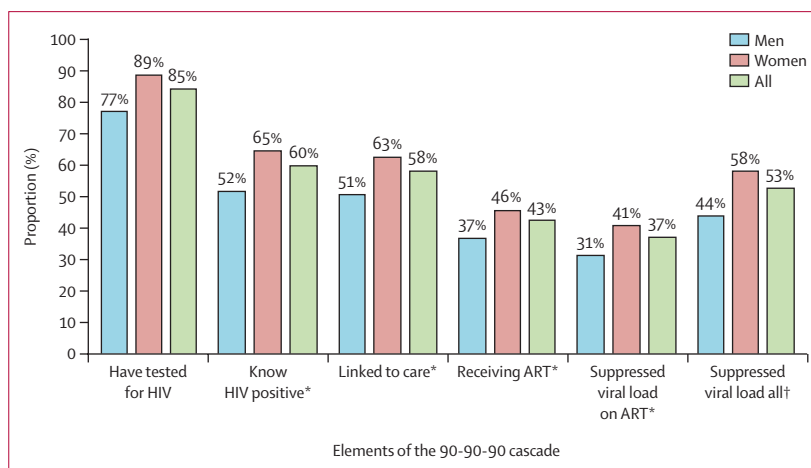
Among HIV-positive participants, 2107 of 3969 (53%, 95% CI 50–56) had viral loads less than 1000 copies per mL, irrespective of ART status, with prevalence being 44% (39–49, 427 of 1014) among men and 58% (55–61, 1680 of 2955) among women ( $p < 0.0001$ ). Among participants who reported taking ART, the proportion with viral loads less than 1000 copies per mL was not significantly different between men and women (85%, 80–90, 294 of 341 vs 90%, 87–92, 1117 of 1249;  $p = 0.12$ ). When laboratory results for the presence of ART were included, the percentages become 89% (85–94, 298 of 331) and 92% (90–94, 1156 of 1248), respectively ( $p = 0.28$ ). 20% of men (16–24, 133 of 669) and 32% of women (29–36, 563 of 1697) who were HIV positive and did not report taking ART had suppressed viral loads ( $p < 0.0001$ ).

For the first target of the UNAIDS 90-90-90 cascade, knowledge of HIV-positive status, attainment in men and women was much lower among people younger than 25 years than among those in older age groups (figure 3, appendix), and for the second element, people who are HIV positive taking ART, attainment was lowest for participants aged 20–24 years. The third element of suppressed viral load was achieved in high proportions of all age groups.

Factors significantly associated with attainment of the overall UNAIDS 90-90-90 targets included female sex, being married or cohabiting, and age 35 years or older (table 3). The same variables were also significantly associated with improved attainment of the first target, which is unsurprising because this target largely affects overall target achievement.

## Discussion

None of the UNAIDS 90-90-90 targets for diagnosis, treatment, and viral suppression were met among HIV-positive participants in our study population. In women, one target was met, with 90% taking ART

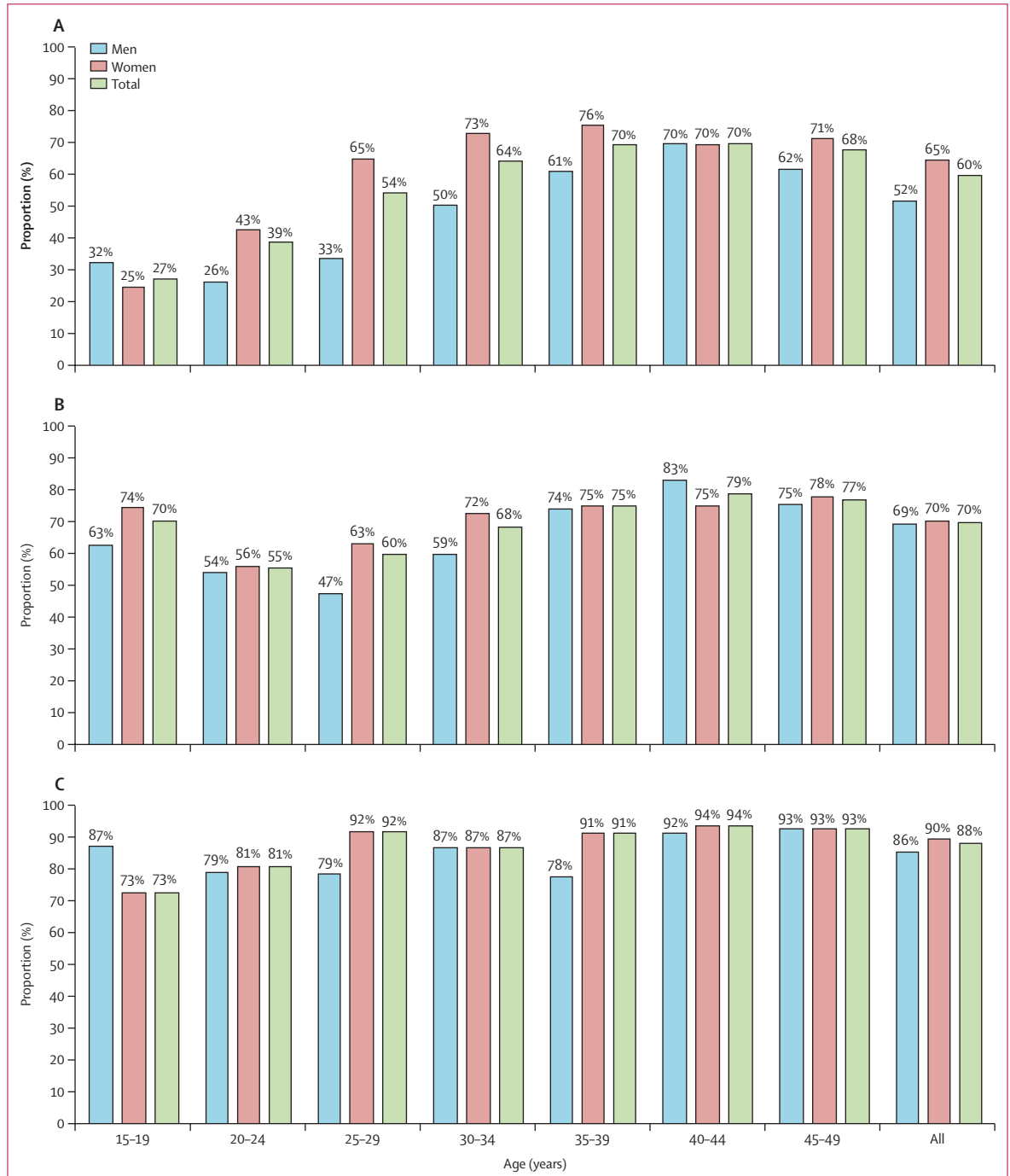


**Figure 2: Cascade of care in participants**

Percentages are based on the number of HIV-positive people and are population weighted. Absolute numbers for each element are available in the appendix. ART=antiretroviral therapy.\*Subset of the element or elements to the left. †Denominator includes HIV-positive people with suppressed viral loads, irrespective of ART status.

having suppressed viral load. This target had also been achieved in 85% of men. By contrast, only 52% of HIV-positive men and 65% of HIV-positive women knew their status, and, of those, 69% and 70%, respectively, reported receiving ART. Only 44% of HIV-positive men

and 58% of HIV-positive women had viral loads less than 1000 copies per mL. The largest shortfall in the linkage to care and treatment cascade, therefore, was the first target, which is the entry point to the health-care system.



**Figure 3: HIV cascade by age group** (A) People living with HIV who know they are HIV positive. (B) People who know they are HIV positive and are taking ART. (C) HIV-positive people taking ART with viral suppression. The absolute numbers for each age group are available in the appendix. ART=antiretroviral therapy.



	People with HIV who know their status	Taking ART*	Suppressed viral load†	Overall suppressed viral load‡
Sex (women vs men)	2.12 (1.75–2.57)	1.17 (0.86–1.58)	1.60 (0.92–2.77)	2.11 (1.69–2.63)
Marital status (married or living together vs single)	1.51 (1.12–2.04)	1.09 (0.81–1.48)	1.13 (0.56–2.27)	1.50 (1.08–2.09)
Age (years)				
15–19 vs 45–49	0.16 (0.09–0.29)	0.82 (0.27–2.51)	0.27 (0.07–1.13)	0.22 (0.13–0.38)
20–24 vs 45–49	0.31 (0.20–0.47)	0.37 (0.23–0.61)	0.28 (0.12–0.68)	0.23 (0.16–0.34)
25–29 vs 45–49	0.62 (0.41–0.93)	0.44 (0.27–0.72)	0.60 (0.23–1.58)	0.32 (0.24–0.44)
30–34 vs 45–49	0.94 (0.67–1.33)	0.68 (0.44–1.03)	0.47 (0.21–1.05)	0.51 (0.37–0.70)
35–39 vs 45–49	1.22 (0.85–1.75)	0.91 (0.57–1.44)	0.48 (0.21–1.09)	0.76 (0.53–1.08)
40–44 vs 45–49	1.21 (0.82–1.78)	1.10 (0.67–1.83)	1.00 (0.45–2.23)	0.94 (0.65–1.36)
Education				
Completed secondary	0.84 (0.57–1.22)	0.82 (0.48–1.39)	1.35 (0.67–2.72)	1.05 (0.74–1.50)
Incomplete secondary	1.44 (0.97–2.15)	0.82 (0.50–1.34)	1.03 (0.55–1.94)	1.19 (0.80–1.75)
No schooling	0.58 (0.32–1.05)	0.65 (0.30–1.41)	6.26 (1.39–28.27)	1.06 (0.61–1.85)
Primary schooling (ref)	1	1	1	1
Away from home for >1 month in past 12 months (no vs yes)	1.00 (0.74–1.36)	0.95 (0.66–1.38)	1.81 (1.13–2.91)	1.29 (0.96–1.73)

ART=antiretroviral therapy. \*Among HIV-positive people who know their status. †Among HIV-positive people taking ART. ‡Respective of ART status or knowledge of HIV status (among all HIV-positive people).

**Table 3: Multivariate odds ratios and 95% CIs for associations between sociodemographic variables and the three elements of the UNAIDS 90-90-90 goals**

UNAIDS has estimated that only 45% of people living with HIV in sub-Saharan Africa know their status.<sup>6</sup> In our study 60% of HIV-positive participants knew their status. Among HIV-infected populations in other countries, 83% in Botswana in 2013–15,<sup>18</sup> 77% in Malawi in 2013,<sup>19</sup> 59% in Kenya in 2012,<sup>20</sup> and 67% in Swaziland<sup>21</sup> have been reported to know their HIV status. A small study in Cape Town, South Africa, in 2010 showed that 55% of HIV-positive people knew their HIV status.<sup>22</sup> When separated by sex, 52% of HIV-positive men and 65% of HIV-positive women in our study reported knowing they were HIV positive. Shisana and colleagues<sup>23</sup> found even lower proportions in South Africa in 2012 (38% of HIV-positive men and 55% of HIV-positive women). In Zambia in 2011–12, 52% of men reported ever having been tested for HIV.<sup>24</sup> Older studies have generally reported poorer knowledge of HIV status, which suggests that availability of HIV testing has increased over time. Botswana is the sub-Saharan country with the highest frequency of HIV diagnosis, reasons for which include high rates of testing in pregnant women and a policy of routine opt-out testing in health-care settings since 2004.<sup>18</sup>

Once people in the KwaZulu-Natal district in our study knew they were HIV positive, linking to the care and treatment cascade was good, with more than 90% having had CD4 cell counts and more than 95% having ever linked to care. The results for the second UNAIDS 90-90-90 target, therefore, were 69% of men and 70% of women receiving ART. By contrast, in Swaziland, 50% of HIV-positive participants were linked to care.<sup>21</sup>

42% of all HIV-positive people in this study (37% of men and 46% of women) reported taking ART, which is

higher than the UNAIDS estimate of 39% of people living with HIV in sub-Saharan Africa.<sup>6</sup> Additionally, Shisana and colleagues<sup>23</sup> reported that 31% of HIV-positive people in South Africa (26% men and 35% women) were taking ART, and Takuva and colleagues<sup>25</sup> estimated that 34% were receiving ART. The PopART study<sup>26</sup> found that 52% and 49% of HIV-positive people were taking ART in an area of the Western Cape province of South Africa and in Zambia, respectively. Other studies found that 63% of HIV-positive people in Malawi<sup>19</sup> and 40% in Kenya<sup>20</sup> were taking ART. Variability in coverage is seen across the entire continent with, for example, coverage of 41% in eastern and southern Africa, 23% in western and central Africa, and 19% in north Africa.<sup>6</sup> One reason for the low ART coverage in most sub-Saharan African countries is the decision to give patients ART based on CD4 cell counts, meaning that many people diagnosed as having HIV were linked to care but ART was not started. Most countries are implementing test-and-treat systems, meaning that ART is started irrespective of CD4 cell count. The number of HIV-positive individuals taking ART is, therefore, expected to increase.

Viral load suppression was seen in 44% and 58% of HIV-infected men and women, respectively, in this study, which is substantially below the UNAIDS target of 73%. In sub-Saharan Africa, the proportion of people living with HIV with suppressed viral loads is estimated to be 29–32%.<sup>6,27</sup> In Swaziland in 2011 the proportion was 35%.<sup>21</sup> In Botswana in 2013–15 it was 70%,<sup>18</sup> in Kenya in 2012 it was 40%,<sup>20</sup> and in South Africa in 2012 it was 25%.<sup>25</sup> Thus, despite high prevalence in the district in South Africa that we assessed, viral suppression was achieved

in more people than in most other countries in the region. This finding can be partly attributed to our survey being done more recently than the other studies, because HIV diagnosis and ART coverage have improved over time. Additionally, many HIV-positive participants claimed not to be taking ART but had viral load suppression.

The greatest success in KwaZulu-Natal was the high proportions of participants taking ART who had achieved viral suppression, with 85% of men and 90% of women having viral loads less than 1000 copies per mL. These proportions are higher than in many developed countries,<sup>27</sup> although lower than the 97% reported in Botswana.<sup>18</sup> It was also much higher than the 26% reported in rural areas of the North West province of South Africa.<sup>28</sup> We assessed ART use by asking participants whether they were currently taking ART. In the analysis of viral suppression, we did not include patients who had started but discontinued ART. We did not collect information on adherence to ART, but the high frequency of viral suppression suggests that it is good. ART is available free of charge at clinics close to where many people in the study area live. The public health system mandates monitoring of viral load to assess treatment success and detect issues with adherence, along with steps to be taken when patients stop taking treatment.<sup>29</sup> These steps include comprehensive adherence counselling, repeated viral-load testing, and switching to second-line treatment.<sup>12</sup>

None of the three UNAIDS 90-90-90 cascade targets had been met in the population we assessed. If service coverage is not increased, South Africa will not be able to reverse the HIV epidemic in this high-burden district. However, the proportions of people who know their HIV status, are receiving ART, and have achieved viral load suppression are all greater than those in a representative sample of South Africa,<sup>23</sup> which suggests that other districts face similar problems.

Knowledge of HIV status was the only target for which the proportion was higher in women than in men. This difference is driven by the testing of women during pregnancy. Men unaware of their HIV status are not linking to care, although once in care they seem to achieve the targets as well as women.

This study was based on a representative sample of the general population in the uMgungundlovu district and, therefore, our findings are generalisable to the whole study area. The greatest limitation of our study is that knowledge of HIV status and ART use were self-reported and, therefore, the data might be susceptible to bias, such as social desirability bias. For example, among 79 participants who reported being HIV negative but had positive HIV tests and were selected for laboratory ART testing, 31 tested positive for the presence of ART. If knowledge of HIV status was under-reported, the proportions of participants who knew their HIV status is an underestimate. Adherence to ART was not assessed

and, therefore, we do not know whether participants who said they were taking ART were receiving adequate doses to achieve viral suppression. Finally, we only assessed people aged 15–49 years, meaning that the results are not generalisable to older or younger people.

Improvement is needed in all aspects of the HIV care and treatment cascade, with emphasis on campaigns to increase HIV testing. Such campaigns should be strengthened by scaling-up of testing in all settings, especially where men and boys can be reached such as mobile testing in communities<sup>30</sup> and workplace testing. The PopART study<sup>31</sup> showed increased uptake of testing was when it was offered in peoples' homes. For instance, one round of home-based testing led to an increase in people knowing their HIV status from 47% to more than 87%. Because HIV testing is done before male circumcision, combining HIV and circumcision campaigns would be cost effective. In our study, many people who claimed to have been tested for HIV reported being HIV negative, yet they had HIV-positive results when tested during the study. This finding indicates the need for repeated testing.

#### Contributors

AK is the principal investigator of the study. AK, CC, and DK were responsible for the field work and quality assurance, AG for statistical analyses, and AP for laboratory testing and quality assurance. AG wrote the first draft of the manuscript. All authors reviewed and contributed to the final version of the manuscript.

#### Declaration of interests

We declare no competing interests.

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