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The prevalence, incidence, and sociodemographic risk factors of HIV among older adults in sub-Saharan Africa (AWI-Gen): a multicentre, longitudinal cohort study

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Summary

Background Sub-Saharan Africa's ageing population includes a rising number of adults aged 50 years and older living with HIV. Although antiretroviral therapy (ART) has extended life expectancy, data on HIV incidence and treatment outcomes among older adults remain scarce. To inform targeted public health interventions, we aimed to examine the prevalence and incidence of HIV, as well as sociodemographic determinants associated with HIV acquisition and treatment outcomes, among older adults in sub-Saharan Africa.

Methods AWI-Gen is a multicentre, longitudinal cohort study. We assessed data from random community-based samples of adults aged 40–60 years collected between Aug 5, 2013, and Aug 19, 2016 (wave 1) and of adults aged 40 years and older collected between Jan 24, 2019, and Nov 23, 2022 (wave 2) from Nairobi (Kenya) and from Soweto, Agincourt, and Dikgale Mamabolo Mothiba (South Africa). Sociodemographic data were collected through interviewer-administered questionnaires and structured interviews. The primary outcome was HIV status at both wave 1 and wave 2, classified as either HIV-positive or HIV-negative. We evaluated the prevalence and incidence of HIV, ART coverage, and self-reported HIV awareness and used logistic regression to examine risk factors associated with HIV acquisition and treatment outcomes.

Findings Among 7919 participants in wave 1 who were recruited and followed up, 6505 (82·1%) participants were aged 40–60 years, of whom 5730 (88·1%) contributed HIV-related data. 3148 (54·9%) participants were women and 2582 (45·1%) were men. In wave 2, 4520 participants from wave 1 were followed up with an additional 579 participants recruited. 5076 (99·5%) participants were aged 40 years and older, of whom 4931 (97·1%) contributed HIV-related data. 2767 (56·1%) participants were women and 2164 (43·9%) were men. Overall, 1271 (22·2%) of 5730 participants in wave 1 and 1073 (21·8%) of 4931 participants in wave 2 were living with HIV, with regional variability (χ^2 p<0·0001) and higher prevalence in women than in men (χ^2 p<0·0001). Prevalence was highest among individuals aged 40–45 years (454 [26·7%] of 1698 participants) in wave 1 and those aged 46–50 years (297 [29·9%] of 994 participants) in wave 2, decreasing significantly in older age groups (χ^2 p<0·0001). Overall HIV incidence was 0·35 per 100 person-years (95% CI 0·26–0·48), with a reduced risk of seroconversion in participants aged 51–55 years (incidence rate ratio [IRR] 0·42 [95% CI 0·17–0·93]; p=0·039) and 56–60 years (0·19 [0·05–0·52]; p=0·0033). Compared with participants with formal education, incidence among those with no formal education was nearly four times higher (IRR 0·96 [95% CI 0·50–1·85] *vs* 0·26 [0·16–0·44]). Women and men residing in rural areas showed consistently higher predicted probabilities of HIV status than their counterparts in urban settings. The accuracy of self-reported HIV-positive status improved from 55·5% (95% CI 51·1–59·8) in wave 1 to 76·7% (73·1–80·0) in wave 2. ART coverage also increased between wave 1 (250 [90·3%] of 277 participants who reported a positive HIV test result) and wave 2 (404 [94·2%] of 429 participants).

Interpretation The findings emphasise the complex interplay of age, education, gender, and location in shaping HIV risk. Although ART coverage has improved, older adults face considerable barriers to HIV prevention, including educational disparities and gender inequities, particularly in rural settings. Tailored interventions targeting older populations are essential to address these gaps because the risk of HIV acquisition, albeit generally lower than in younger populations, remains noteworthy.

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Introduction

Global public health efforts, including education campaigns, improved testing, prevention strategies, and life-saving antiretroviral therapy (ART), have advanced the prevention and treatment of HIV,[1] particularly in low-income and middle-income countries. Despite these gains, sub-Saharan

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For the Kiswahili translation of the abstract see Online for appendix 1

For the Xitsonga translation of the abstract see Online for appendix 2

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Research in context

Evidence before this study

HIV research in sub-Saharan Africa has predominantly focused on younger populations and pregnant women, leaving gaps in understanding the experiences of older adults living with HIV (aged ≥50 years). Following the success of antiretroviral therapy (ART) in extending life expectancy, populations with HIV aged 50 years and older have grown rapidly. We systematically searched PubMed and Scopus, without language restrictions, for studies published between Jan 1, 2000, and Dec 31, 2024, using the terms: "HIV prevalence," "HIV incidence," "older adults," "aging population," "sub-Saharan Africa," "antiretroviral therapy coverage," and "sociodemographic factors". We reviewed the existing literature and identified key gaps. One study highlighted the increasing prevalence of HIV among older adults in Africa and provided estimates of the burden within this demographic. Similarly, another study attempted to address the gap by estimating HIV incidence and exploring challenges in extending HIV care to older populations. A further study noted a geographical bias in research, with studies disproportionately conducted in eastern and southern Africa. This work also explored the effect of sociodemographic factors, such as age and education levels, on the HIV epidemic in ageing populations. Another study identified barriers to the uptake of HIV testing among older adults, emphasising the pervasive effect of stigma, which delays diagnosis and limits access to care. The South African Human Sciences Research Council's report from the sixth South African National HIV Prevalence, Incidence and Behaviour Survey report offers valuable insights into national HIV prevalence, viral load suppression, and progress towards the 95-95-95 targets. However, the report primarily focused on individuals aged 15–49 years, leaving older populations under-represented. Furthermore, most studies in sub-Saharan Africa are cross-sectional, limiting their ability to track temporal changes or evaluate the effectiveness of ART coverage in older populations. There is a crucial need for longitudinal data to better understand the dynamics of HIV among older populations, particularly in urban and rural contexts across sub-Saharan Africa.

Added value of this study

This study provides longitudinal insights into the HIV epidemic among older adults in sub-Saharan Africa. Unlike previous studies that predominantly focused on younger populations, this work highlights unique sociodemographic disparities, differences between urban and rural populations, and protective factors influencing HIV prevalence, incidence, and ART coverage over time. By leveraging nearly a decade of follow-up data, this study advances the existing knowledge base on the evolving dynamics of HIV epidemiology in ageing populations and underscores the crucial role of longitudinal data in shaping targeted interventions.

Implications of all the available evidence

These findings emphasise the need for tailored HIV prevention and treatment programmes that address the specific challenges faced by older adults in sub-Saharan Africa, such as stigma, scarce health-care access, and disparities in ART coverage. Policy makers and health-care providers need to incorporate age-specific strategies, integrate considerations for urban versus rural populations, expand HIV testing and awareness campaigns, and improve ART accessibility for this growing demographic. Additionally, the results highlight the importance of addressing sociodemographic inequities, such as education and socioeconomic status, to reduce the risk of HIV acquisition and transmission. Integrating these insights into public health frameworks can help to close gaps in achieving the UNAIDS 95-95-95 targets and ensure equitable health-care access for all age groups.

Africa still has a disproportionate burden of HIV, with eastern and southern Africa most affected.[2] ART has transformed the diagnosis of HIV into a chronic condition, extending life expectancy[3] and reducing viral load and transmission across populations. Nevertheless, older adults (aged ≥50 years) remain an under-represented and at-risk demographic in the HIV epidemic.[2]

The number of adults aged 50 years and older living with HIV in sub-Saharan Africa doubled between 2000 and 2016. By 2040, 25% of people living with HIV in the region will be aged 50 years and older.[4] Despite this growing recognition, national HIV surveys primarily focus on individuals younger than 50 years, leaving considerable gaps in understanding HIV prevalence, incidence, and treatment outcomes in older populations. Studies suggest that HIV prevalence among individuals aged 50–59 years is similar to or even exceeds that of younger adults,[5] with evidence of increasing prevalence among the older population in Kenya (from 7·8% in 2007 to 9·1% in 2012), South Africa (14% in 2022), and Botswana (from 24·6% in 2013 to 35·7% in 2021).[6–10] These prevalence estimates highlight improved survival due to ART, hence the demographic shifts and overlooked risks of new HIV infections in older adults.[11]

Although previous studies have reported HIV prevalence in older adults, few studies have investigated longitudinal incidence trends or the interplay between sociodemographic factors, such as education, marital status, and socioeconomic status.[11,12] Education offers some protection against HIV acquisition, whereas poverty, unemployment, stigma, and scarce health-care access exacerbate susceptibility in older populations.[12] Furthermore, sparse data exist on how HIV testing accuracy and treatment coverage evolve in ageing populations, particularly in rural versus urban settings.[5,13] Older adults are less likely to perceive themselves as at risk of HIV, a challenge compounded by HIV programmes that primarily target younger individuals.[5,12] Therefore, tailored interventions addressing these gaps are crucial for mitigating risks in this population.

Efforts to achieve the UNAIDS 95-95-95 targets have improved HIV awareness and ART coverage in sub-Saharan Africa,[14] particularly in South Africa and Kenya. Between 2017 and 2022, South Africa increased HIV awareness from 80% to 94% and ART coverage from 63·7% to 80·9%,[9] and Kenya achieved similar gains.[15] These targets primarily focus on individuals younger than 50 years, underrepresenting older adults in progress assessments.[14,16] Barriers such as comorbidities, stigma, and health-care access further hinder progress for this age group, emphasising the need for targeted public health interventions to ensure that they are not left behind in the HIV response.[5]

We aimed to examine the prevalence and incidence of HIV, as well as the sociodemographic determinants associated with HIV acquisition and treatment outcomes, among older adults in sub-Saharan Africa.[17] By synthesising data from the Africa Wits–INDEPTH Partnership for Genomic Research (AWI-Gen) from adults aged 40 years and older, we provide a comprehensive analysis of HIV epidemiology in older populations, addressing gaps in sociodemographic determinants, treatment coverage, and the accuracy of self-reported HIV status. These findings aim to inform evidence-based strategies for addressing the evolving dynamics of HIV and AIDS in ageing populations across sub-Saharan Africa.

Methods

Study design and participants

AWI-Gen is a multicentre, longitudinal cohort study conducted at six research centres in four sub-Saharan Africa countries (South Africa, Kenya, Burkina Faso, and Ghana) to investigate various health determinants.[17] Although the AWI-Gen study was originally designed to investigate genomic and environmental determinants of cardiometabolic diseases, this present analysis focuses on HIV-related outcomes only.

We used data collected in urban Kenya and in urban and rural sites across South Africa during two waves of data collection: from Aug 5, 2013, to Aug 19, 2016 (wave 1) and from Jan 24, 2019, to Nov 23, 2022 (wave 2). We performed an analysis of HIV-related data from participants aged 40 years and older at selected sites with sufficient data on HIV prevalence. These sites were the South African Medical Research Council–Wits Developmental Pathways for Health Research Unit in Soweto, South Africa, and three health demographic surveillance system sites (the Medical Research Council–Wits Agincourt and Dikgale Mamabolo Mothiba [DIMAMO] in South Africa and Nairobi Urban Health Demographic Surveillance System in Kenya).[17] Health demographic surveillance system sites in west Africa (ie, Nanoro in Burkina Faso and Navrongo in Ghana) were excluded due to low national HIV prevalence.

In wave 1, adults aged 40–60 years who had been residing in the catchment area for more than 10 years and were unrelated to other study participants were randomly selected to participate in the study by use of population sampling frames with equal sex distribution. In wave 2, participants who had completed follow-up from wave 1 and additional adults aged 40 years and older were eligible to participate. Further details on participant eligibility criteria and sampling are provided in the appendix 3 (pp 3–4) and have been described previously.[17] All participants provided written informed consent.

See Online for appendix 3

Ethical approval was obtained from the University of the Witwatersrand Human Research Ethics Committee (M121029, M2210108, and M170880) and ethical bodies in each country. Relevant ethical approval was also obtained from the HAALSI study[18] to access HIV diagnoses among participants from Agincourt who were also enrolled in the AWI-Gen study during wave 2.

Procedures and outcomes

Participants completed interviewer-administered questionnaires that captured sociodemographic characteristics, health history, and HIV testing and treatment. During wave 2, data were collected through structured interviews with locally trained fieldworkers who captured responses into the Research Electronic Data Capture system in real time. Other HIV-related data included awareness of HIV status and risk factors for transmission, as well as self-reported use of ART. Detailed information on the HIV questionnaire module is provided in the appendix 3 (pp 4–6).

The primary outcome was the HIV status of all eligible participants at both wave 1 and wave 2, classified as either HIV-positive or HIV-negative. This classification was determined through participant self-reports or voluntary HIV rapid tests (Determine HIV-1/2 immunoassay [Abbott Diagnostics Medical, Chiba-ken, Japan]), confirmed with the Uni-Gold HIV-1/2 test (Trinity Biotech Manufacturing, Bray, Ireland). For participants from Agincourt in wave 2, HIV status was assessed with dried blood spot testing due to overlap with the HAALSI study,[18] which was conducted at the same site. Briefly, HIV screening was done with the Vironostika HIV 1/2 Ag/AbMicroELISA System (BioMérieux, Marcy-l'Étoile, France) and confirmatory ELISA with the Cobas E411 Combi Ag (Roche, Basel Diagnostics International, Rotkreuz, Switzerland).

The following sociodemographic factors were included as explanatory variables: sex (as assigned at birth); age (40–45 years, 46–50 years, 51–55 years, or 56–60 years); marital status (married or living together, never married or cohabitated, divorced or separated, or partner deceased); education level (no formal education, primary education [typically completed by age 12–14 years], or secondary [typically completed by age 18–19 years] or higher education [typically started at age 19–20 years]); employment status (unemployed or employed); and socioeconomic status, which was based on household assets stratified into five quintiles (where the first quintile represented the poorest and the fifth quintile represented the wealthiest).

Statistical analysis

The study aimed to recruit 12 000 participants to achieve over 94% power (α=0·05) for genetic and phenotypic

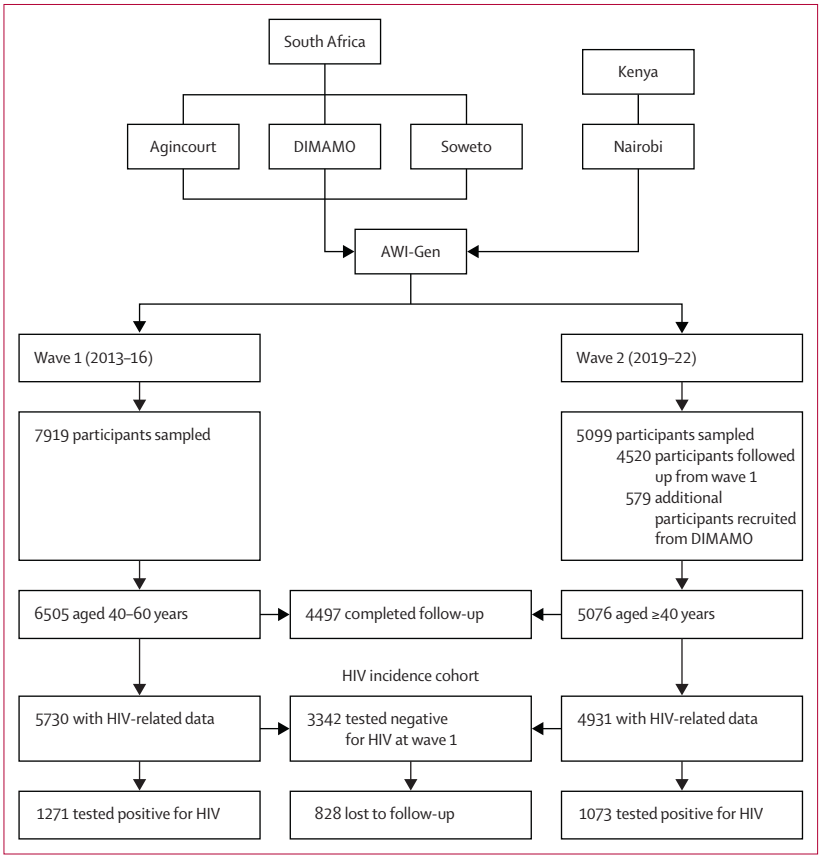


Figure 1: **Study profile for wave 1 (2013–16) and wave 2 (2019–22)**
The number of participants who contributed HIV-related data at wave 1 (aged 40–60 years) and wave 2 (aged ≥40 years) were included in the cross-sectional analysis for calculating HIV prevalence and in the longitudinal analysis for calculating HIV incidence. The site in Kenya was Nairobi Urban Health Demographic Surveillance System; the sites in South Africa were the South African Medical Research Council–Wits Developmental Pathways for Health Research Unit, Medical Research Council–Wits Agincourt, and DIMAMO. DIMAMO=Dikgale Mamabolo Mothiba.

analyses. HIV prevalence was calculated as the proportion of individuals who tested positive for HIV. We used logistic regression models to identify factors associated with HIV infection at both wave 1 and wave 2, treating HIV status as a binary outcome of interest (either HIV-positive or HIV-negative). Univariate models were initially run to screen for associations, followed by multivariable models to adjust for confounders (appendix 3 p 6). We identified candidate predictors using a stepwise selection approach with a liberal threshold ($p \leq 0{\cdot}20$) for entry and retention, which was guided by previous literature and the study's objectives. This approach ensured the inclusion of known risk factors and potential confounders associated with HIV infection. Age was modelled categorically to align with intervention strategies targeting specific age groups, supported by model fit comparisons and sensitivity analyses (appendix 3 pp 10–13). Predicted probabilities of HIV infection were calculated to assess the interactions between demographic variables.

HIV incidence was calculated over person-years exposed at follow-up among participants who tested negative for HIV during wave 1 (appendix 3 pp 6–7). Poisson regression was applied to estimate incidence rate ratios (IRRs) for demographic and behavioural covariates. The natural logarithm of follow-up time was included as an offset to model rates per unit of person-time. Robust SEs were applied to address potential overdispersion.

We assessed the accuracy of self-reported HIV status using point-of-care HIV test results as the reference standard. Sensitivity measured the proportion of true positive results identified by self-reports, whereas specificity captured the proportion of true negative results (appendix 3 p 7). Positive predictive values assessed the likelihood of accurate self-reports among individuals who identified as living with HIV; negative predictive values assessed the likelihood of accurate self-reports among those who identified as HIV-negative.

The treatment cascade was evaluated based on self-reported HIV status and ART use (appendix 3 p 7). We calculated the proportion of participants with HIV who had initiated ART at each stage and corresponding 95% CIs to assess precision and trends over time. For proportions, odds ratios (ORs), and IRRs, we calculated 95% CIs using the Wald method on the logarithmic scale. We obtained 95% CIs for IRRs by exponentiating the log-scale limits to ensure accuracy of the reported estimates. All statistical analyses were performed with Stata SE (version 18).

Role of the funding source

The funders of the study had no role in study design, data collection, data analysis, data interpretation, or writing of the report.

Results

During wave 1, 7919 participants were recruited from Nairobi (Kenya) and Agincourt, Soweto, and DIMAMO (South Africa). 6505 (82·1%) participants were aged 40–60 years, of whom 5730 (88·1%) contributed HIV-related data (figure 1; appendix 3 p 8). 3148 (54·9%) participants were women and 2582 (45·1%) were men, with a median age of 50 years (IQR 45–54; table 1). Overall, 1271 (22·2%) of all 5730 participants had HIV, with prevalence varying significantly across study centres: 234 (13·9%) of 1683 participants with data tested positive for HIV in the Nairobi Urban Health Demographic Surveillance System (Kenya) compared with 1037 (25·6%) of 4047 participants across the South African sites (χ^2 $p<0{\cdot}0001$; table 1). In terms of study sites, Agincourt had the highest prevalence of HIV, followed by DIMAMO. Women had a significantly higher prevalence than men (χ^2 $p<0{\cdot}0001$; table 1). Prevalence varied significantly across age groups, from 454 (26·7%) of 1698 participants aged 40–45 years to 188 (16·4%) of 1143 aged 56–60 years (χ^2 $p<0{\cdot}0001$). In terms of marital status, HIV prevalence was highest among widowed participants and lowest among married participants (table 1). Regarding education level and socioeconomic status, participants with no formal education and those in the second socioeconomic quintile had the highest prevalence.

During wave 2, 4520 participants were followed up and an additional 579 participants were recruited from DIMAMO, totalling 5099 participants (figure 1). 5076 (99·5%) of these participants were aged 40 years and older, of whom 4931 (97·1%) contributed HIV-related data (figure 1; appendix 3 p 9). Median age was 57 years (IQR 51–63), reflecting the inclusion of older participants in wave 2 compared with wave 1. HIV prevalence was slightly lower in wave 2 than in wave 1 with 1073 (21·8%) participants testing positive overall: 213 (18·1%) of 1179 participants with data were from the Nairobi Urban Health Demographic Surveillance System and 860 (22·9%) of 3752 were from sites across South Africa (table 2). In terms of study sites, Agincourt continued to record the highest prevalence, followed by DIMAMO (table 2). Similarly, women continued to have a higher prevalence than men (table 2). Regarding age groups, prevalence was highest among those aged 46–50 years (297 [29·9%] of 994 participants) and lowest among those aged 70 years and older (36 [8·9%] of 405 participants). Marital status remained a significant factor, with widowed and never-married participants showing higher prevalence than married participants (χ^2 p<0·0001; table 2).

Older age showed a protective effect against HIV infection in both waves 1 and 2, with significantly lower odds of infection observed among participants aged 50–60 years and older (figure 2). This protective effect was strongly influenced by the participants' level of education (appendix 3 p 15). Participants with no formal education had the highest probabilities of HIV infection across all age groups, particularly in wave 1 (appendix 3 p 15). By wave 2, this disparity persisted, with participants aged 40–45 years and 46–50 years who had never received a formal education remaining at the highest risk of HIV (appendix 3 p 15). By contrast, participants who had received secondary or higher education showed a marked decrease in the predicted probabilities of HIV infection across age groups in both waves, underscoring the protective role of education (appendix 3 p 15).

Sex differences in HIV risk were also influenced by rural and urban residence, with notable interactions when age was considered (appendix 3 p 16). In wave 1, women living in rural areas showed the highest probabilities of HIV infection across most age groups, whereas their counterparts in urban settings showed a reduction in risk from age 56 years and older. By wave 2, both men and women living in urban settings had lower probabilities of HIV infection than those in rural areas, regardless of age (appendix 3 p 16). This rural–urban divide was most pronounced among younger women (aged 40–45 years and 46–50 years), emphasising the persistent susceptibilities associated with residence and gender.

Broader protective factors against HIV infection included being married, being employed, having formal education—particularly secondary or higher education—and having high socioeconomic status. In wave 1, participants in the fifth quintile showed the lowest odds of infection; in wave 2,

	Total (n=5730)	HIV-positive participants (n=1271)	HIV-negative participants (n=4459)	p value
Sex				
Female	3148/5730 (54·9%)	763/3148 (24·2%)	2385/3148 (75·6%)	<0·0001
Male	2582/5730 (45·1%)	508/2582 (19·7%)	2074/2582 (80·3%)	..
Age, years	50 (45–54)	48 (44–53)	50 (45–55)	..
Age group, years				
40–45	1698/5730 (29·6%)	454/1698 (26·7%)	1244/1698 (73·3%)	<0·0001
46–50	1438/5730 (25·1%)	321/1438 (22·3%)	1117/1438 (77·7%)	..
51–55	1451/5730 (25·3%)	308/1451 (21·2%)	1143/1451 (78·8%)	..
56–60	1143/5730 (19·9%)	188/1143 (16·4%)	955/1143 (83·6%)	..
Country of origin				
Kenya	1683/5730 (29·4%)	234/1683 (13·9%)	1449/1683 (86·1%)	<0·0001
South Africa	4047/5730 (70·6%)	1037/4047 (25·6%)	3010/4047 (74·4%)	..
Study site				
Agincourt	1423/5730 (24·8%)	486/1423 (34·2%)	937/1423 (65·8%)	<0·0001
DIMAMO	1142/5730 (19·9%)	247/1142 (21·6%)	895/1142 (78·4%)	..
Nairobi	1683/5730 (29·4%)	234/1683 (13·9%)	1449/1683 (86·1%)	..
Soweto	1482/5730 (25·9%)	304/1482 (20·5%)	1178/1482 (79·5%)	..
Ethnicity				
Tsonga	1373/5730 (24·0%)	453/1373 (33·0%)	920/1373 (67·0%)	<0·0001
BaPedi	1140/5730 (19·9%)	243/1140 (21·3%)	897/1140 (78·7%)	..
Kikuyu	628/5730 (11·0%)	94/628 (15·0%)	534/628 (85·0%)	..
Zulu	533/5730 (9·3%)	122/533 (22·9%)	411/533 (77·1%)	..
Kamba	342/5730 (6·0%)	27/342 (7·9%)	315/342 (92·1%)	..
Sotho	326/5730 (5·7%)	80/326 (24·5%)	246/326 (75·5%)	..
Luo	289/5730 (5·0%)	60/289 (20·8%)	229/289 (79·2%)	..
Luhya	264/5730 (4·6%)	37/264 (14·0%)	227/264 (86·0%)	..
Tswana	216/5730 (3·8%)	43/216 (19·9%)	173/216 (80·1%)	..
Xhosa	159/5730 (2·8%)	39/159 (24·5%)	120/159 (75·5%)	..
Swati	111/5730 (1·9%)	25/111 (22·5%)	86/111 (77·5%)	..
Venda	72/5730 (1·3%)	8/72 (11·1%)	64/72 (88·9%)	..
Kisii	59/5730 (1·0%)	4/59 (6·8%)	55/59 (93·2%)	..
Somali	38/5730 (0·7%)	3/38 (7·9%)	35/38 (92·1%)	..
Ndebele	36/5730 (0·6%)	9/36 (25·0%)	27/36 (75·0%)	..
Meru	27/5730 (0·5%)	8/27 (29·6%)	19/27 (70·4%)	..
Embu	18/5730 (0·3%)	1/18 (5·6%)	17/18 (94·4%)	..
Other	29/5730 (0·5%)	1/29 (3·4%)	28/29 (96·6%)	..
Missing data	70/5730 (1·2%)	14/70 (20·0%)	56/70 (80·0%)	..
Marital status				
Married or living together	3343/5730 (58·3%)	605/3343 (18·1%)	2738/3343 (81·9%)	<0·0001
Never married or cohabitated	747/5730 (13·0%)	204/747 (27·3%)	543/747 (72·7%)	..
Divorced or separated	925/5730 (16·1%)	252/925 (27·2%)	673/925 (72·8%)	..
Partner deceased	568/5730 (9·9%)	175/568 (30·8%)	393/568 (69·2%)	..
Missing data	147/5730 (2·6%)	35/147 (23·8%)	112/147 (76·2%)	..
Employment status				
Employed	3406/5730 (59·4%)	648/3406 (19·0%)	2758/3406 (81·0%)	<0·0001
Unemployed	2244/5730 (39·2%)	599/2244 (26·7%)	1645/2244 (73·3%)	
Missing data	80/5730 (1·4%)	24/80 (30·0%)	56/80 (70·0%)	
Education level				
No formal education	613/5730 (10·7%)	175/613 (28·5%)	438/613 (71·5%)	<0·0001
Primary education	2385/5730 (41·6%)	537/2385 (22·5%)	1848/2385 (77·5%)	..
Secondary or higher education	2658/5730 (46·4%)	545/2658 (20·5%)	2113/2658 (79·5%)	..
Missing data	74/5730 (1·3%)	14/74 (18·9%)	60/74 (81·1%)	..

(Table 1 continues on next page)

	Total (n=5730)	HIV-positive participants (n=1271)	HIV-negative participants (n=4459)	p value
(Continued from previous page)				
Socioeconomic status by quintile				
First (lowest)	724/5730 (12·6%)	179/724 (24·7%)	545/724 (75·3%)	<0·0001
Second	1259/5730 (22·0%)	341/1259 (27·1%)	918/1259 (72·9%)	..
Third	951/5730 (16·6%)	204/951 (21·5%)	747/951 (78·5%)	..
Fourth	1232/5730 (21·5%)	282/1232 (22·9%)	950/1232 (77·1%)	..
Fifth (highest)	1517/5730 (26·5%)	258/1517 (17·0%)	1259/1517 (83·0%)	..
Missing data	47/5730 (0·8%)	7/47 (14·9%)	40/47 (85·1%)	..

Data are n/N (%) or median (IQR). DIMAMO=Dikgale Mamabolo Mothiba.

Table 1: **Sociodemographic characteristics of participants who contributed data in wave 1 (2013–16)**

	Total (n=4931)	HIV-positive participants (n=1073)	HIV-negative participants (n=3858)	p value
Sex				
Female	2767/4931 (56·1%)	641/2767 (23·2%)	2126/2767 (76·8%)	0·0076
Male	2164/4931 (43·9%)	432/2164 (20·0%)	1732/2164 (80·0%)	..
Age, years	57 (51–63)	54 (50–60)	57 (51–64)	..
Age group, years				
40–45	158/4931 (3·2%)	31/158 (19·6%)	127/158 (80·4%)	<0·0001
46–50	994/4931 (20·2%)	297/994 (29·9%)	697/994 (70·1%)	..
51–55	1046/4931 (21·2%)	269/1046 (25·7%)	777/1046 (74·3%)	..
56–60	1046/4931 (21·2%)	239/1046 (22·8%)	807/1046 (77·2%)	..
61–65	871/4931 (17·7%)	137/871 (15·7%)	734/871 (84·3%)	..
66–70	411/4931 (8·3%)	64/411 (15·6%)	347/411 (84·4%)	..
>70	405/4931 (8·2%)	36/405 (8·9%)	369/405 (91·1%)	..
Country of origin				
Kenya	1179/4931 (23·9%)	213/1179 (18·1%)	966/1179 (81·9%)	0·0005
South Africa	3752/4931 (76·1%)	860/3752 (22·9%)	2892/3752 (77·1%)	..
Study site				
Agincourt	1210/4931 (24·5%)	389/1210 (32·1%)	821/1210 (67·9%)	<0·0001
DIMAMO	1161/4931 (23·5%)	220/1161 (18·9%)	941/1161 (81·1%)	..
Nairobi	1179/4931 (23·9%)	213/1179 (18·1%)	966/1179 (81·9%)	..
Soweto	1381/4931 (28·0%)	251/1381 (18·2%)	1130/1381 (81·8%)	..
Ethnicity				
Tsonga	1143/4931 (23·2%)	362/1143 (31·7%)	781/1143 (68·3%)	<0·0001
BaPedi	1166/4931 (23·6%)	217/1166 (18·6%)	949/1166 (81·4%)	..
Kikuyu	461/4931 (9·3%)	66/461 (14·3%)	395/461 (85·7%)	..
Zulu	841/4931 (17·1%)	170/841 (20·2%)	671/841 (79·8%)	..
Kamba	186/4931 (3·8%)	25/186 (13·4%)	161/186 (86·6%)	..
Sotho	210/4931 (4·3%)	45/210 (21·4%)	165/210 (78·6%)	..
Luo	239/4931 (4·8%)	73/239 (30·5%)	166/239 (69·5%)	..
Luhya	178/4931 (3·6%)	37/178 (20·8%)	141/178 (79·2%)	..
Tswana	130/4931 (2·6%)	28/130 (21·5%)	102/130 (78·5%)	..
Xhosa	88/4931 (1·8%)	13/88 (14·8%)	75/88 (85·2%)	..
Swati	86/4931 (1·7%)	14/86 (16·3%)	72/86 (83·7%)	..
Venda	39/4931 (0·8%)	3/39 (7·7%)	36/39 (92·3%)	..
Kisii	38/4931 (0·8%)	3/38 (7·9%)	35/38 (92·1%)	..
Somali	35/4931 (0·7%)	3/35 (8·6%)	32/35 (91·4%)	..
Ndebele	20/4931 (0·4%)	3/20 (15·0%)	17/20 (85·0%)	..
Meru	17/4931 (0·3%)	5/17 (29·4%)	12/17 (70·6%)	..
Other	29/4931 (0·6%)	2/29 (6·9%)	27/29 (93·1%)	..
Missing data	25/4931 (0·5%)	4/25 (16·0%)	21/25 (84·0%)	..

(Table 2 continues on next page)

participants in the third quintile had the lowest odds of infection (figure 2). By contrast, being South African (adjusted OR 2·38 [95% CI 1·98–2·86] in wave 1 and 1·98 [1·60–2·46] in wave 2) and widowed (1·75 [1·35–2·27] in wave 1 and 1·41 [1·11–1·80] in wave 2) were consistently associated with higher odds of HIV (figure 2). Although men had slightly lower odds of acquiring HIV in wave 1 than did women (0·94 [0·81–1·08]), they had marginally higher odds in wave 2 (1·04 [0·89–1·02]; figure 2).

Among 3342 participants who tested negative for HIV during wave 1 (figure 1), 40 (1·2%) participants showed seroconversion at wave 2, resulting in an overall HIV incidence of 0·35 cases per 100 person-years (95% CI 0·26–0·48; table 3). Poisson regression showed a protective effect of older age, with significantly lower risks of seroconversion among participants aged 51–55 years (IRR 0·42 [95% CI 0·17–0·93]; p=0·039) and 56–60 years (0·19 [0·05–0·52]; p=0·0033) than among those aged 40–45 years (0·53 [0·21–1·21]; p=0·14). HIV incidence was highest among participants who were divorced or separated, those with no formal education, and those with the lowest socioeconomic status, although these observations were not significant (table 3). By contrast, the incidence of HIV was overestimated when self-reported HIV status was included in the incidence estimate for a cohort of 3529 participants who were HIV-negative at wave 1 (by test or self-report) and followed up in wave 2 by use of both HIV testing and self-reported status (appendix 3 p 14).

The accuracy of self-reported HIV-positive status improved between wave 1 and wave 2. Sensitivity increased from 55·5% (95% CI 51·1–59·8) in wave 1, with a positive predictive value of 91·4% (87·7–94·1), to 76·7% (73·1–80·0) in wave 2, with a positive predictive value of 95·2% (92·8–96·8). Specificity was high in wave 1 at 98·9% (98·3– 99·2), with a negative predictive value of 91·0% (89·8–92·1), and remained high in wave 2 at 99·3% (99·9–99·5), with a negative predictive value of 96·0% (95·3–96·6).

Improvements in HIV testing accuracy contributed to progress along the treatment cascade. At wave 1, 535 (70·7%; 95% CI 67·3–73·9) participants with HIV reported ever testing for HIV, of whom 503 (94·0%; 91·7–95·7) knew their HIV status (appendix 3 p 17). However, only 277 (55·1%; 51·0–59·9) participants self-reported as testing positive for HIV. 250 (90·3%; 86·1–93·5) of these individuals reported being on ART, resulting in 50·2% ART coverage (appendix 3 p 17). By wave 2, awareness of HIV status improved significantly, with 554 (98·6%; 97·2–99·4) participants with HIV reporting having ever tested for HIV and 547 (98·7%; 97·4–99·5) knowing their status (appendix 3 p 17). The proportion of the cohort self-reporting as testing positive for HIV increased to 429 (78·4%; 74·7–81·8) participants. 404 (94·2%; 91·5–96·2) of these individuals reported being on ART, resulting in 74·7% ART coverage. Despite these improvements, gaps in completing the treatment cascade persisted, particularly among men and unmarried participants (appendix 3 pp 17–18). Awareness of their HIV status within the treatment cascade remained

highest among women (172 [62·1%] of 277 in wave 1 and 263 [61·3%] of 429 in wave 2) and married participants (143 [51·6%] of 277 in wave 1 and 166 [38·7%] of 429 in wave 2).

Discussion

Our study leverages longitudinal data from the AWI-Gen study to provide insights into the prevalence and incidence of HIV, the accuracy of self-reported HIV status, and ART coverage in adults aged 40 years and older in sub-Saharan Africa. Our findings show significant sociodemographic disparities, emphasising the unique challenges that older adults face in the HIV epidemic. This study's focus on older populations with HIV addresses a crucial gap in HIV research, given that most studies prioritise younger populations.[10,19]

Baseline findings showed an HIV prevalence of 22·2% with significant regional variability: 13·9% in Kenya and 25·6% in South Africa. Other studies have reported a prevalence of 9–14% among older adults in Kenya[6,7] and 14% in South Africa.[9] The rise in HIV prevalence in Nairobi between wave 1 and wave 2 observed in this current study diverges from the decreasing trend reported in national surveys,[15] probably due to different study populations, urban migration patterns, and challenges in achieving comprehensive ART coverage and addressing structural barriers in urban populations across Kenya.[10] Our findings align with existing patterns of regional HIV prevalence, with South Africa consistently showing higher HIV burdens than neighbouring countries (eg, Namibia, Mozambique, and Zimbabwe).[8,9,20] The higher prevalence in rural South African sites, such as Agincourt (34·2%), compared with urban areas, such as Soweto (20·5%), contrasts with urban-centric studies in sub-Saharan Africa,[9,12,19,21] which report increased prevalence in urban areas. Our findings suggest that rural populations face unique barriers to HIV prevention and treatment, such as stigma, health-care shortages, and economic disparities.[21] The slight decrease in prevalence at follow-up might be attributed to improved ART coverage and adherence, with reduced transmission rates.[9,22]

Consistent with previous studies,[9,11] this study showed that HIV prevalence was higher among women than men at both baseline (24·2% *vs* 19·7%) and follow-up (23·2% *vs* 20·0%). This gender disparity is rooted in women's higher biological susceptibility to HIV (eg, increased mucosal surface area), which facilitates viral transmission,[23] as well as social and cultural vulnerabilities (including economic dependence, gender-based violence, and unequal power dynamics in sexual relationships, which limit women's ability to negotiate safer sex practices).[9,11] Age-related trends further highlight the complexity of the epidemic, with a prevalence of 19% among individuals aged 50 years and older in the current study. HIV prevalence was highest among participants aged 40–45 years (26·7%) but reduced among those aged 56–60 years (16·5%), reflecting survivorship bias and reduced sexual activity in older age groups,[16,19] which is consistent with earlier studies.[20,23–25] Widowed individuals showed the highest prevalence (30·8%), reflecting the compounded impact of spousal loss to HIV-related illnesses, stigma surrounding widowhood, and increased vulnerability to high-risk behaviours (eg, transactional sex, reduced condom negotiation power, and new partnerships with potentially unknown HIV status).[26] Prevalence was increased in participants who had not received a formal education and in those with low socioeconomic status, which might be due to scarce access to health care and poor knowledge and awareness of HIV risk factors and prevention strategies.[12,27]

This study's estimate of HIV incidence, although relatively low at 0·35 cases per 100 person-years, underscores ongoing transmission among middle-aged and older adults (aged ≥40 years). This rate is consistent with findings from the HAALSI study, which reported an incidence of 0·39 cases per 100 person-years.[25,28] The observed reduction in incidence with increasing age aligns with other cohort studies.[25,28] However, the highest incidence observed among divorced or separated participants, those with no formal education, and those with low socioeconomic status highlight the importance of addressing structural barriers to HIV prevention. With sparse data on incidence among older adults,[9] these vulnerabilities are compounded in this

	Total (n=4931)	HIV-positive participants (n=1073)	HIV-negative participants (n=3858)	p value
(Continued from previous page)				
Marital status				
Married or living together	2569/4931 (52·1%)	421/2569 (16·4%)	2148/2569 (83·6%)	<0·0001
Never married or cohabitated	771/4931 (15·6%)	216/771 (28·0%)	555/771 (72·0%)	..
Divorced or separated	664/4931 (13·5%)	171/664 (25·8%)	493/664 (74·2%)	..
Partner deceased	922/4931 (18·7%)	265/922 (28·7%)	657/922 (71·3%)	..
Missing data	5/4931 (0·1%)	0	5/5 (100·0%)	..
Employment status				
Employed	1859/4931 (37·7%)	393/1859 (21·1%)	1466/1859 (78·9%)	0·42
Unemployed	3065/4931 (62·2%)	679/3065 (22·2%)	2386/3065 (77·8%)	..
Missing data	7/4931 (0·1%)	1/7 (14·3%)	6/7 (85·7%)	..
Education level				
No formal education	697/4931 (14·1%)	180/697 (25·8%)	517/697 (74·2%)	0·0077
Primary education	1689/4931 (34·3%)	375/1689 (22·2%)	1314/1689 (77·8%)	..
Secondary or higher education	2540/4931 (51·5%)	518/2540 (20·4%)	2022/2540 (79·6%)	..
Missing data	5/4931 (0·1%)	0	5/5 (100·0%)	..
Socioeconomic status by quintile				
First (lowest)	439/4931 (8·9%)	144/439 (32·8%)	295/439 (67·2%)	<0·0001
Second	2911/4931 (59·0%)	654/2911 (22·5%)	2257/2911 (77·5%)	..
Third	1052/4931 (21·3%)	165/1052 (15·7%)	887/1052 (84·3%)	..
Fourth	207/4931 (4·2%)	46/207 (22·2%)	161/207 (77·8%)	..
Fifth (highest)	322/4931 (6·5%)	64/322 (19·9%)	258/322 (80·1%)	..

Data are n (%) or median (IQR). DIMAMO=Dikgale Mamabolo Mothiba.

Table 2: **Sociodemographic characteristics of participants who contributed data in wave 2 (2019–22)**

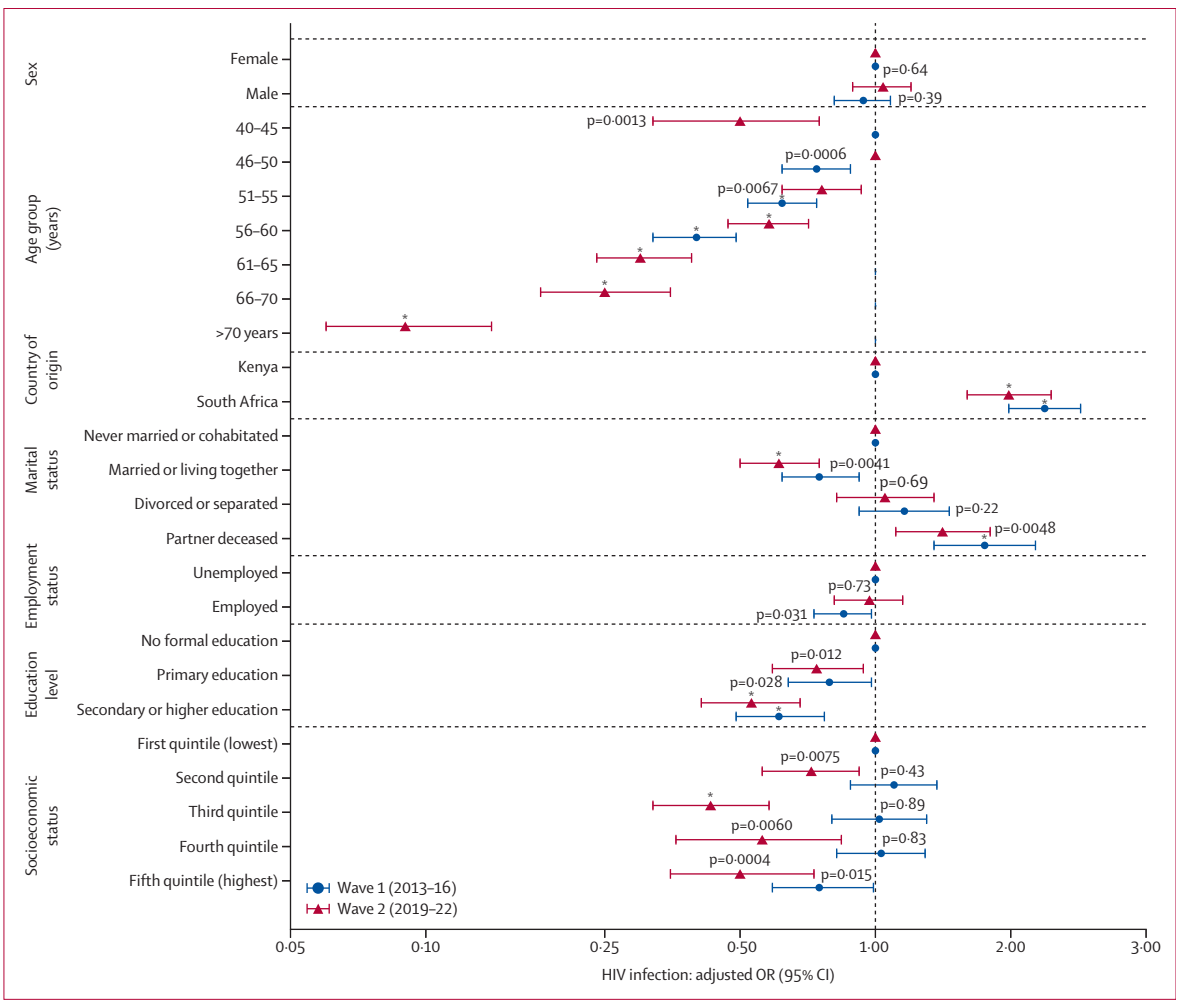


Figure 2: **Adjusted ORs for HIV infection across sociodemographic factors in wave 1 (2013–16) and wave 2 (2019–22)**
Adjusted ORs and 95% CIs for HIV infection are provided across various demographic and socioeconomic factors, stratified by wave 1 (2013–16) and wave 2 (2019–22). The x-axis represents the adjusted ORs for HIV infection on a logarithmic scale, with the dashed vertical line indicating an OR of 1 (no association). OR=odds ratio. *p<0·0001.

population who might be overlooked by prevention efforts typically aimed at younger age groups.[23] Widowed participants were at particularly high risk of acquiring HIV (adjusted OR 1·75 [95% CI 1·35–2·27]), consistent with previously reported associations between widowhood and both risk-taking behaviours and economic instability.[26]

Improving the accuracy of self-reported HIV status is crucial for achieving ART coverage and viral suppression, especially in high-stigma settings.[29,30] The sensitivity of HIV self-reports increased from 55·5% in wave 1 to 76·7% in wave 2, reflecting not only improved testing campaigns and reduced stigma but also considerable under-reporting that could have hindered linkage to treatment.[31,32] Although sensitivity and specificity are foundational metrics for assessing the performance of diagnostic tools,[33] predictive values remain valuable when an individual's true disease status is unknown at the time of testing, even if they can be influenced by disease prevalence.[33] High specificity and predictive values suggest that self-reports remain a reliable tool for identifying HIV-negative individuals and reducing HIV transmission,[29,30,33,34] while facilitating accurate linkage to treatment and care services.[34] With some studies highlighting the limitations of self-reported data,[30,34] these findings highlight the need for routine testing to complement self-reports in older adults, for whom stigma or lack of knowledge can impede the accurate self-reporting of data. Routine testing could therefore improve outcomes and ensure efficient use of resources.[29,30,34]

The HIV treatment cascade showed progress but fell short of the UNAIDS 95-95-95 targets, particularly in self-reporting HIV status.[14] In wave 1, 55·5% of people living with HIV self-reported their HIV-positive status, with women and married individuals showing highest awareness. By wave 2, awareness improved to 78·4% likely due to community outreach and educational efforts, but still remained below target levels.[32] ART coverage increased from 90·3% in wave 1 to 94·2% in wave 2, bordering achieving the second UNAIDS target reflecting improved

	Cases	Person-years	IR (95% CI) per 100 person-years	IRR (95% CI) per 100 person-years	p value
Overall HIV incidence	40	11 335	0·35 (0·26–0·48)	..	..
Sex					
Male	17	4964	0·34 (0·21–0·55)	1·58 (0·78–3·14)	0·19
Female	23	6371	0·36 (0·24–0·54)	1 (ref)	..
Age group, years					
40–45	10	3057	0·33 (0·17–0·61)	0·53 (0·21–1·20)	0·14
46–50	17	2929	0·58 (0·36–0·93)	1 (ref)	..
51–55	9	2761	0·32 (0·17–0·63)	0·42 (0·17–0·93)	0·039
56–60	4	2587	0·15 (0·06–0·41)	0·19 (0·05–0·52)	0·0033
Study site					
Agincourt	15	2320	0·65 (0·39–1·07)	1 (ref)	..
DIMAMO	16	2753	0·58 (0·36–0·95)	1·49 (0·65–3·43)	0·34
Nairobi	4	1987	0·20 (0·07–0·54)	0·29 (0·08–0·94)	0·050
Soweto	5	4275	0·12 (0·05–0·28)	0·24 (0·07–0·71)	0·013
Marital status					
Never married or cohabitated	4	1528	0·26 (0·09–0·70)	0·45 (0·10–1·37)	0·21
Married or living together	26	6603	0·39 (0·27–0·58)	1 (ref)	..
Divorced or separated	6	1858	0·32 (0·14–0·72)	1·31 (0·46–3·20)	0·58
Partner deceased	4	891	0·45 (0·17–1·19)	1·10 (0·31–2·97)	0·87
Employment status					
Unemployed	17	4873	0·35 (0·22–0·56)	1 (ref)	..
Employed	21	6356	0·33 (0·21–0·51)	1·36 (0·67–2·74)	0·39
Education level					
No formal education	9	934	0·96 (0·50–1·85)	2·18 (0·81–5·52)	0·11
Primary education	16	4509	0·35 (0·22–0·58)	1 (ref)	..
Secondary or higher education	15	5664	0·26 (0·16–0·44)	0·68 (0·32–1·48)	0·33
Socioeconomic status by quintile					
First (lowest)	8	1306	0·61 (0·31–1·22)	1 (ref)	..
Second	9	2475	0·36 (0·19–0·70)	0·60 (0·22–1·70)	0·32
Third	3	1727	0·17 (0·06–0·54)	0·35 (0·07–1·30)	0·14
Fourth	7	2358	0·30 (0·14–0·62)	0·49 (0·16–1·46)	0·19
Fifth (highest)	13	3329	0·39 (0·23–0·67)	0·67 (0·25–1·91)	0·43

Conservative estimates of exposure include exposure estimates for 828 people who were not tested during wave 2 (Jan 24, 2019–Nov 23, 2022) and lost to follow-up. DIMAMO=Dikgale Mamabolo Mothiba. IR=incidence rate. IRR=incidence rate ratio.

***Table* 3: HIV IRs and adjusted IRRs from wave 1 to wave 2 (2013–22) across key sociodemographic covariates**

outreach and linkage to care, as well as enhanced adherence support.[14] However, persistent gaps were noted among men, younger age groups, and unmarried participants, suggesting how tailored interventions to bridge these disparities are required. Age-specific trends showed high ART uptake among older participants (aged 51–70 years), reflecting improved adherence and engagement with care but a shortfall in overall ART coverage.[12,21] The scarcity of data in older adults makes it difficult to assess progress towards these targets.[14,21,22] Therefore, efforts are necessary to address the social determinants of health, improve sex education and community-based testing, and reduce stigma, particularly among older adults.[31]

Several limitations might have influenced these findings. Missing data on HIV status led to the exclusion of some participants and loss to follow-up could have introduced bias, particularly with the incidence estimates. However, data missingness in predictor variables was minimal (<1%), limiting potential bias. Cross-sectional components are subject to incidence-prevalence bias, potentially underestimating the occurrence of recent HIV infections. Additionally, unmeasured confounders, such as sexual behaviour, condom use, and stigma, might have influenced the risk of HIV acquisition and transmission. Changes in HIV prevention strategies, health-care access, and societal attitudes over the follow-up period could also have affected prevalence and awareness. Furthermore, the absence of data on virological suppression (the third 95 UNAIDS target) limits insights into the full treatment cascade for older adults.

This study expands the evidence base for understanding HIV in ageing populations in sub-Saharan Africa, highlighting crucial risk factors and disparities in prevalence, incidence, and treatment uptake. Addressing structural barriers, enhancing routine community-based testing and

interventions, and reducing stigma are important steps towards achieving equitable progress in the global HIV response. Targeted strategies should prioritise women, widowed individuals, and those with low socioeconomic status and no formal education, while ensuring that older adults are included in prevention and treatment initiatives. Although progress has been made towards reaching UNAIDS targets, intensified efforts are needed to meet the 2030 goals.

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Contributors

FXG-O, SH, ST, NC, and MR conceptualised the study, secured funding for the resources, designed the methodology, and obtained necessary ethics approval. LAIO curated, verified, and validated the data; performed the formal analysis; produced the figures; and wrote the original draft. TM performed initial data quality control, verification, and validation. BH and CK guided the analyses. SFM, IK, CK, SSC, CBN, LKM, and FDT organised the resources and logistics at each study centre and contributed to community engagement, ethical approval, participant enrolment, investigation, and project administration. FXG-O verified the data, supervised the work, guided the analyses, and reviewed and edited the manuscript. All authors reviewed, edited, and approved the submitted version of the manuscript. All authors had full access to all the data in the study and had final responsibility for the decision to submit for publication.

Declaration of interests

SH reports grants to the Wits Health Consortium from GSK and Novartis, for work unrelated to HIV. All other authors declare no competing interests.

Data sharing

De-identified, individual participant, baseline data from the AWI-Gen study are available from the European Genome-Phenome Archive (accession number EGA00001002482). The Human Heredity and Health in Africa Data and Biospecimen Access Committee will review requests for the AWI-Gen phenotype dataset. Related documents, including the study protocol and statistical analysis plan, will be available upon request to the corresponding author.

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