Introduction

Global public health efforts including education campaigns, improved testing, and lifesaving treatment programs, have significantly advanced the fight against HIV/AIDS, particularly in low- and middle-income countries. However, sub-Saharan Africa (SSA) still bears a disproportionate burden of the disease, with limited healthcare resources. Within this region, Eastern and Southern Africa are most affected, with Kenya and South Africa being particularly impacted. Despite similarities in demographics and healthcare systems, these countries differ in HIV epidemiology due to cultural practices, healthcare infrastructure, and policy implementation. Lifelong antiretroviral therapy (ART) has transformed HIV into a manageable chronic condition, improving life expectancy for people living with HIV (PLWH). While increased ART coverage reduces population viral load and transmission, further efforts are needed to eliminate HIV as a public health threat.

Efforts to achieve the UNAIDS 95-95-95 targets have focused on ensuring 95% of PLWH are diagnosed, on ART, and achieve viral suppression. Regionally, eastern and southern regions are on track with central and western regions lagging. South Africa has significantly improved HIV status awareness from 80% to 94% and increased ART coverage from 68% to 75% between 2018 and 2021. Similarly, Kenya's HIV status awareness rose from 79·5% to 94%, with ART coverage increasing from 76·3% to 94% in the same period. South Africa has also made progress in achieving virological suppression but still faces challenges in expanding treatment access to meet global targets.

This longitudinal study examines HIV prevalence and incidence from the first and second waves of the Africa Wits-INDEPTH Partnership for Genomic Studies (AWI-Gen) in urban and rural sites in Kenya and South Africa. By synthesizing existing evidence, we detail the current status of the HIV epidemic in AWI-Gen adult cohorts, identify key determinants of transmission, and highlight areas for targeted public health intervention. Our findings will inform policymakers, healthcare practitioners, and stakeholders in developing evidence-based strategies to mitigate HIV/AIDS in older subjects in SSA.

Methods

Study centres, design, and population

For this study we use data from the AWI-Gen two-wave longitudinal cohort study in SAMRC/Wits Developmental Pathways for Health Research Unit (DPHRU) in Soweto, the MRC/Wits Agincourt HDSS and the Dikgale Mamabolo Mothiba (DIMAMO) in South Africa, as well as the Nairobi Urban HDSS (NUHDSS) in Kenya.

Baseline recruitment of participants occurred from August 2011 to August 2016 (Wave-1) and included 7,919 individuals, with 6,505 aged 40-60 years. A follow-up study (Wave-2) was conducted between January 2019 and October 2022, with an additional ~600 participants recruited from DIMAMO. Participants completed interviewer-administered questionnaires in Wave-1 and the Research Electronic Data Capture (REDCap) tool was used in Wave-2 to collect sociodemographic characteristics, along with HIV testing and treatment information.

Main outcome and selected explanatory variables

The study's outcome variable was HIV status, classified as either HIV-positive or HIV-negative. This status was determined through participant self-reporting or from the results of a voluntary HIV rapid test (Determine™ HIV–1/2, confirmed with Uni-Gold™ HIV-1/2) at both Wave-1 and Wave-2. However, for Agincourt participants in Wave-2, HIV status was assessed using dried blood spots (DBS) testing due to the overlap with the Health and Aging in Africa: a Longitudinal Study of the INDEPTH Community in South Africa (HAALSI) at the same site. The AWI-Gen Agincourt participants were also enrolled in the HAALSI study (2021-2022), and ethical approval was obtained to access their Wave-2 HIV diagnosis from the HAALSI study.

Explanatory variables included sociodemographic factors: sex (as assigned at birth), age (categorized into 40-45, 46-50, 51-55, and 56-60 years), marital status (married/living together, never married, divorced/separated, partner deceased), education level (no formal education, primary, secondary or higher), employment status (unemployed or employed), and socioeconomic status (SES), based on household assets and stratified into quintiles.

Statistical analysis

This study determined HIV prevalence at Wave-1 and Wave 2, the treatment cascade, and the incidence of HIV in cohorts aged 40-60 years longitudinally between Wave-1 and Wave 2. Multinomial logistic regression was used to identify factors associated with HIV infection at both time points. HIV incidence was calculated over person-years exposed at follow-up, with Poisson regression used to analyse associations with demographic and behavioural covariates. The treatment cascade was evaluated through self-reported HIV status and ART usage, with proportions and confidence intervals calculated for each stage. The validity of self-reported HIV status was assessed against POC-HIV test results, calculating sensitivity, specificity,

positive predictive value (PPV), and negative predictive value (NPV) to measure accuracy. The detailed methods are in the supplementary information. Statistical analyses were conducted using STATA/SE software version 18 (Stata Corp, College Station, TX, USA).

Results

Prevalence in Wave-1 and Wave-2

In Wave-1 of the study, 6,505 participants aged 40-60 years were included, with 5,730 (88%) having HIV status. The cohort comprised 54·9% women, with an average age of 49·7 years (SD 5·7). The overall HIV prevalence was 22·2%, varying between the study centres: 13·9% in the NUHDSS in Kenya, and 25·6% in the South African centres. Among the South African participants, HIV prevalence was highest in Agincourt (34·2%) and DIMAMO (21·6%). Women had a higher HIV prevalence (24·2%) compared to men (19·7%). Age-wise, HIV prevalence was highest among those aged 40-45 years (26·7%) and lowest in the 56-60 year age group (16·5%).

Over 5.79 years (±SD 0.91) mean time of follow-up, 4,426 baseline participants aged 40+ years were retained, with an additional 650 new participants recruited from DIMAMO. Wave-2 included 5,076 participants aged 40+ years, with 4,931 (97%) having confirmed HIV status. The overall HIV prevalence in Wave-2 was 21·8%, with 18% in the NUHDSS and 22·9% in South African centres. Agincourt continued to have the highest prevalence (32·2%), followed by DIMAMO (18·9%). The mean age of Wave-2 participants was 57·7 years (SD 8·7). Women again had a higher HIV prevalence (23·2%) than men (20%). Prevalence was highest among those aged 46-50 years (29·9%) and lowest in those aged 70+ years (8·9%).

Risk factors associated with HIV infection

In Wave-1, the odds of being HIV-positive were analysed relative to seven sociodemographic variables. The adjusted odds ratios (aOR) revealed that increasing age (aOR 0·40; 95% CI: 0·32 - 0·49), being married (aOR 0·75; 95% CI: 0·62 - 0·91), employment (aOR 0·85; 95% CI: 0·73 - 0·98), having some formal education (aORs 0·79 and 0·61; 95% CIs: 0·63 - 0·97 and 0·49 - 0·77), and belonging to a higher wealth quintile (aOR 0·75; 95% CI: 0·59 - 0·94) were protective factors against HIV infection. Conversely, being South African (aOR 2·37; 95% CI: 1·97 - 2·87) and having a deceased partner (aOR 1·75; 95% CI: 1·35 - 2·27) were associated with higher odds of being HIV-positive. Although men had slightly lower odds of being HIV-positive than women (aOR 0·93; 95% CI: 0·81 - 1·08), this difference was not statistically significant.

In Wave-2, the pattern was similar, with some shifts. Being male (aOR 1·03; 95% CI: 0·89 - 1·20) showed a slight, non-significant increase in the odds of being HIV-positive. Protective factors included increasing age (aOR 0·40; 95% CI: 0·32 - 0·49), being married (aOR 0·61; 95% CI: 0·50 - 0·75), having some formal education (aORs 0·52 and 0·74; 95% CIs: 0·41 - 0·68 and 0·58 - 0·93), and being in the third wealth quintile or higher (aOR 0·43; 95% CI: 0.32-0.58). Higher odds of being HIV-positive were still observed among South Africans (aOR 1·98; 95% CI: 1·59 - 2·46) and those with a deceased partner (aOR 1·41; 95% CI: 1·11 - 1·80). Employment status did not show a significant association with HIV status in Wave-2.

HIV treatment cascades

In Wave-1, 55% (n=277) of HIV-positive participants tested via POC were aware of their status, falling short of the first 95% UNAIDS target. Awareness was higher among females (62%) and married participants (51·6%). Of those aware of their status, 90% (n=250, 95% CI: 86 - 93) were receiving ART, with females comprising 61·2% of this group. This results in an ART coverage of approximately 50%.

By Wave-2, awareness improved, with 77% (n=432, 95% CI: 74 - 81) of HIV-positive POC/DBS tested participants knowing their status, though still below the UNAIDS target. Awareness remained higher among females (61%) and among married participants (38.7%). Among those aware, 95% (n=407, 95% CI: 92 - 96) were on ART, with females representing 61·4%. This increased the proportion of ART coverage to 74% at Wave-2.

HIV seroconversion

From a cohort of 3,342 participants who tested HIV-negative at baseline, 828 participants were LTFU, and 40 participants seroconverted, resulting in an overall HIV incidence rate of 0·35 per 100 person-years [95% CI: 0·26 - 0·48]. Age emerged as a protective factor, with older participants [51-55 years, IRR = 0·42 (CI: 0·18 - 0·95), 56-60 years, IRR = 0·19 (CI: 0·06 - 0·57)] showing a significantly lower risk of seroconversion compared to those in their 40s. Although not statistically significant, higher risks of HIV infection were observed among participants who were divorced or separated (IRR = 1·31 CI: 0·51 - 3·39), employed (IRR = 1·35 CI: 0·68 - 2·72), had no formal education (IRR = 2·18 CI: 0·85 - 5·61), and were in the poorest SES.

Discussion

Our study leverages longitudinal data from the AWI-Gen study to provide a comprehensive analysis of HIV prevalence, incidence, accuracy of self-reported HIV status, and ART coverage

in adults aged 40+ in urban Kenya and rural and urban South Africa. We found significant variations in HIV prevalence and risk factors across different demographics and socioeconomic groups, offering additional insights into the evolving HIV epidemic in SSA. Unlike most studies that focus on younger populations, our research emphasizes the older demographic, highlighting the unique challenges they face in the context of HIV epidemiology.

The baseline findings revealed an HIV prevalence of 22·2% among older adults, with significant differences between the Kenyan (13·9%) and South African (25·6%) cohorts. These figures align with regional HIV trends, particularly highlighting South Africa's higher burden, which is well-documented.[11] The notably higher prevalence in rural areas like Agincourt (34·2%) and DIMAMO (21·6%) compared to the urban South African site, Soweto (20·5%) underscores the localized nature of the epidemic, necessitating targeted public health interventions. At follow-up, the overall prevalence slightly decreased to 21·8%, yet regional and demographic disparities persisted, with the prevalence in Nairobi increasing and the prevalence in South African centres decreasing. These differences could be linked to a reduction in viral load and transmission as a result of improved ART coverage or improved HIV testing and prevention programs in South Africa. This highlights the continued need for focused efforts to address the local epidemic among older populations

The longitudinal follow-up findings revealed an HIV incidence rate of 0·35 per 100 person-years exposed, which, while relatively low, is significant given the age of the study population. This rate is consistent with findings from similar settings [0.39 per 100 person-years], indicating ongoing transmission among middle-aged adults. The observed reduction in incidence with increasing age aligns with other cohort studies. However, the higher risk of HIV infection among older adults who are divorced or separated, have no formal education and belong to the poorest SES highlights a complex interplay of socioeconomic and behavioural factors. These vulnerabilities are compounded in older adults, who may be overlooked by prevention efforts typically aimed at younger populations.

This study observed significant progress in HIV testing, awareness, and treatment coverage over time, yet it also highlights ongoing challenges in meeting the 95-95-95 UNAIDS targets, particularly in self-reporting of HIV status. In Wave-1 the HIV program fell short of the first 95 UNAIDS target with only 55% of PLWH self-reporting as being HIV-positive. The significant improvement of the first 95 UNAIDS targets from 55% in Wave-1 to 78% in Wave-2 was likely due to increased HIV testing campaigns and better access to information, which helped reduce stigma and improve testing uptake. Moreover, the study's findings are encouraging, with 90% of PLWH on ART in Wave-1, increasing to 95% in Wave-2, achieving

the second 95 UNAIDS target. This achievement reflects improved outreach, better linkage to care, and enhanced adherence support but with a shortfall in the overall ART coverage particularly among subgroups (older adults) less likely to be on treatment.

Several limitations may have impacted the study, including missing HIV status data and participants' LTFU, which could introduce bias and reduce statistical power, particularly in incidence estimation. The study's focus on specific socio-demographic indicators may not fully capture the complexity of behavioral factors affecting HIV risk, such as sexual partners and condom use.