

Geospatial and Sociodemographic Disparities in HIV Prevalence and HIV Diagnosis Among Men in Zimbabwe Using ZIMPHIA 2020 Data

Ellen Danai Mukwekwerere

e.d.mukwekwerere@wustl.edu

Washington University School of Medicine

Ellen Wakisa Nyasulu Chiwoni

Washington University School of Medicine

Elizabeth Nakiyingi

Northeastern University

Peter Kalulu

Washington University School of Medicine

Redvers Kadzungwa

Boston University School of Public Health

Rubanga David Atube

Makerere University

Bernard F. Banda

Washington University in St. Louis

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Abstract

Introduction

Although Zimbabwe is among the countries on track to end the HIV epidemic by 2030, important gaps remain. Recent disruptions in HIV funding risk reversing decades of progress. Understanding disparities in the HIV burden and care is crucial for optimizing resource allocation.

Methods

We used data from the ZIMPHIA 2020 survey. Among the 7,664 men included in the study, we estimated survey-weighted descriptive statistics and HIV prevalence across sociodemographic characteristics. The first 95 target was assessed by sociodemographic characteristics, while all 95–95–95 targets were described and mapped. Multivariable logistic regression was performed to identify factors associated with HIV awareness status. Spatial autocorrelation and hotspot analyses were used to assess geographic clustering.

Results

HIV prevalence among men was 10.2% (95% CI: 9.5%–11.0%). Among HIV-positive men ($n = 906$), 84.3% were aware of their status, 95.9% of those aware were on ART, and 89% of those on ART were virally suppressed. HIV prevalence was highest among men aged 45 + years (21.1%; 95% CI: 19.1%–23.2%). Conversely, unawareness was highest among men aged 15–24. Each additional year reduced the odds of unawareness by 9% (OR = 0.91; 95% CI: 0.88–0.94). HIV prevalence was highest in the Matabeleland provinces, with significant spatial clustering and hotspots. Unawareness was highest in Mashonaland Central and Masvingo, with no significant clustering.

Conclusion

Our findings suggest that men lag behind in HIV care, especially in diagnosis. There is sociodemographic and geographic heterogeneity in HIV prevalence and unawareness among men, hence resource allocation should be targeted accordingly.

Clinical Trial: Not Applicable

Introduction

Over the last two decades, there has been remarkable progress in the global response to the human immunodeficiency virus (HIV). Since 2010, the incidence of HIV has been reduced by 40% while HIV related deaths have been reduced by 56% globally [1]. The Joint United Nations Programme on HIV/AIDS (UNAIDS) established the 95-95-95 targets as a framework to end the acquired immunodeficiency syndrome (AIDS) epidemic by 2030, with 95% of people living with HIV knowing their status, 95% of those diagnosed receiving sustained antiretroviral therapy (ART), and 95% of those on treatment

achieving viral suppression. Globally, remarkable gains have been made towards achieving these targets, with 87% of all People Living with HIV (PLWHIV) being aware of their status, 89% of those aware of their status receiving ART, and 94% of those who are on ART being virally suppressed[2][4]. However, these global averages mask significant regional and sub-population disparities across gender and key populations, particularly in sub-Saharan Africa, which bears the greatest burden (67%) of the HIV epidemic [2].

While the sub-Saharan Africa region carries the greatest burden of the epidemic, it has also had the overall strongest response to HIV, as well as notable challenges in this fight [2]. For example, more than half of all the 9.2 million people who require but are not on ART reside in this region [1]. Zimbabwe, in particular, is a great example of both the successes and persistent challenges of HIV programming in high-burden regions. With an adult HIV prevalence of approximately 12% in 2020, Zimbabwe has one of the highest HIV burdens globally [3]. It is noteworthy that Zimbabwe has made substantial investments in HIV testing, treatment expansion, and viral load monitoring infrastructure. By the end of 2024, it was one of the seven countries to have achieved the 95-95-95 targets, to have reduced HIV incidence by 75%, and to remain on track to reduce new cases by 90% by 2030, all of which are strong benchmarks for sustainably controlling this epidemic [4].

Despite these gains, national-level progress continues to mask persistent disparities in the HIV burden and care cascade across population subgroups and geographic areas in the country. In particular, a well-documented feature of the HIV epidemic in sub-Saharan Africa is the persistent gender gap in the HIV cascade outcomes, with men consistently having worse outcomes compared to women across testing, linkage to care, ART initiation, and viral suppression [5, 6]. Men are disproportionately affected across this care cascade. Specifically, only 95% of HIV-positive men are aware of their status compared to 98% of women, 91% of men requiring treatment are on ART versus 98% of women, and 86% of men on ART achieve viral suppression compared to 97% of women [1, 7]. Furthermore, research from sub-Saharan Africa has shown that men were twice as likely as women to present with stage 4 HIV at diagnosis [8]. This disparity has been attributed to multiple factors, including health-seeking behaviors shaped by masculine norms that discourage healthcare utilization, HIV related stigma and isolation, and lack of adequate support for men [9–13]. This leads to not only poor health outcomes for men but also to ongoing HIV transmission, as undiagnosed and untreated men contribute greatly to new infections [14].

While national HIV data provide important performance indicators, they may mask considerable geographic variability that is important for targeted programming, especially in the current climate of reduced HIV external funding [15, 16]. HIV prevalence, testing coverage, and treatment outcomes vary across provinces and districts in Zimbabwe. These differences are driven by factors including urbanization patterns, healthcare infrastructure, historical migration routes, as well as cultural practices [17]. A previous study has identified geographic "hotspots" of HIV prevalence, transmission, and gaps in care[18]. However, few studies have combined sex-disaggregated cascade analyses with subnational mapping to identify geographic hotspots of gaps in the HIV care cascade among men, the population with the greatest gaps. Identifying provinces and communities where men face the greatest barriers to

HIV diagnosis and treatment is essential for geographically targeting interventions and efficient resource allocation [19].

This study uses data from the Zimbabwe Population-based HIV Impact Assessment (ZIMPHIA) 2020 study, to provide a comprehensive analysis of HIV prevalence and cascade performance among men, with particular attention to subnational geographic variation and sociodemographic determinants. Our aims include: (1) to estimate HIV prevalence among men and to assess differences across sociodemographic characteristics, (2) to examine progress towards the UNAIDS 95-95-95 targets among HIV positive men, with particular attention to gaps in the first 95 target (HIV awareness), (3) to identify sociodemographic factors independently associated with unawareness of HIV status, among HIV-positive men; and (4) to describe geographic clustering of HIV prevalence and unawareness gaps to inform targeted intervention strategies. By focusing specifically on men, this study characterizes and quantifies male-specific gaps across the HIV testing and treatment cascade as well as subnational variation in Zimbabwe. This study will help inform targeted and efficient allocation of HIV resources under the current constrained funding conditions for policy and program implementation.

METHODS

Study design

We conducted a cross-sectional analysis using secondary data from the 2020 ZIMPHIA study, which is a household-based, nationally representative survey among adults aged 15 years or older. The ZIMPHIA study assesses the national response to HIV using key HIV-related health indicators [3]. The survey is led by the Ministry of Health and Child Care (MoHCC) with technical support from the Centers for Disease Control and Prevention (CDC) and funding from the President's Emergency Plan for AIDS Relief. The ZIMPHIA 2020 study was conducted between November 2019 and March 2020.

The study sampling methods have been described in detail elsewhere [3]. The study employed a two-stage stratified cluster sampling design to generate population-representative estimates of HIV-related indicators. The strata were the 10 provinces in Zimbabwe (Bulawayo, Manicaland, Mashonaland Central, Mashonaland East, Mashonaland West, Matabeleland North, Matabeleland South, Midlands, Masvingo, and Harare). In the first stage, probability proportional to size was used to select 356 enumeration areas (EAs) (also referred to as the Primary Sampling Units (PSUs) or clusters) from the 30,736 EAs created during the 2012 Zimbabwe Population Census [20]. Each EA contained an average of 130 households and 512 persons. Households were randomly selected from each cluster during the second stage of sampling. A total of 11,707 households were selected, of which 89.1% of them completed an interview. From the households, there were 22,751 eligible adults (13,290 women and 9,461 men), and 19,535 (11,871 women and 7,664 men) were surveyed, resulting in a 76.5% response rate (79.6% for women and 72.2% for men). The survey collected, from all consenting participants, individual-level questionnaire data and biomarker specimens, including blood samples for HIV testing; detection of ART (efavirenz,

nevirapine, atazanavir, and dolutegravir) for those who tested positive; and viral load quantification for those on ART.

Study Population

The analytic sample for this study included 7,664 men aged 15 years or older who completed the interview and had valid HIV biomarker data (Fig. 1). Participants with incomplete HIV testing data through either refusal or laboratory issues were excluded from the study. For analyses of the HIV care continuum, the analytic sample was further restricted to the 906 men with a definitive laboratory-confirmed HIV-positive result. To provide context for the analysis, national estimates of HIV prevalence and progress toward the UNAIDS 95–95–95 targets were first described for all adults and disaggregated by sex, before focusing on men as the primary population of interest.

Outcome variables

The key outcome variables were HIV prevalence and HIV status awareness, the first of the UNAIDS 95–95–95 targets. The other two UNAIDS targets were included in descriptive analyses to depict cascade performance. The 1st 95 (HIV status awareness), defined as the proportion of HIV positive men who were aware of their status (aware vs unaware), the 2nd 95 (ART uptake), defined as the proportion of men on ART among those who were aware of their status (on ART vs not on ART), and the 3rd 95 (Viral load suppression), defined as the proportion of men who were virally suppressed (< 1000 copies/ml) among those on ART (suppressed vs unsuppressed)

Information on HIV status, antiretroviral therapy use, and viral suppression was assessed using laboratory-based biomarker testing during the ZIMPHIA 2020 survey [3]. All consenting participants were tested for HIV and classified as HIV-positive based on confirmatory results from the national HIV testing algorithm [21]. Samples from individuals with confirmed HIV infection were subsequently tested for the presence of antiretroviral drugs and for viral load to determine treatment status and viral suppression [21]. Individuals were classified as aware of their HIV-positive status if they self-reported a prior HIV-positive diagnosis or had antiretroviral drugs detected in their blood [22]. Antiretroviral therapy use was defined as either self-reported current ART use or the presence of antiretroviral drugs in blood. Viral load suppression was defined as an HIV ribonucleic acid (RNA) level of $< 1,000$ copies/ml [3].

Denominators for the key indicators varied across HIV care continuum stages. For HIV prevalence, the denominator included all participants with valid HIV test results. For awareness (First 95), the denominator was restricted to HIV-positive participants with non-missing awareness status. For ART uptake (Second 95), the denominator included HIV-positive participants who were aware of their status and had no missing ART data. For viral load suppression (Third 95), the denominator comprised HIV-positive participants on ART with available viral load results.

Covariates

Sociodemographic covariates included: age group (15–24, 25–44, ≥ 45 years), province (Bulawayo, Manicaland, Mashonaland Central, Mashonaland East, Mashonaland West, Matabeleland North, Matabeleland South, Midlands, Masvingo, Harare), residence (urban or rural), education level (primary school or below, high school or higher), household wealth quintile (lowest, second, middle, fourth, highest), and marital status (married/cohabiting, widowed, divorced/separated/single) and voluntary medical male circumcision (VMMC) (circumcised, not circumcised). Urban areas included cities, municipalities, town councils, and other recognized urban centers. All other enumeration areas were classified as rural. The wealth index was constructed using principal component analysis of household asset ownership, housing characteristics, and access to basic services (e.g., drinking water and sanitation). It was divided into five equal wealth quintiles: Poorest, Second, Middle, Fourth, and Richest, with each quintile representing 20 percent of households nationally, ordered from lowest to highest relative wealth.

Statistical Analysis

Data analysis was conducted using R version 4.4.0. The ZIMPHIA 2020 complex survey design (weights, strata, PSU) was applied to all estimates, including 95% CIs. The survey package in R was used to run the weighted analyses. The 95-95-95 targets (including 95% CIs) of the HIV care continuum were estimated for the overall sample of all HIV positive persons and subsequently disaggregated by gender to depict disparities. While overall estimates were stratified by sex (Supplement Table 1), thereafter, our primary analytic focus was men aged 15 years or older with valid HIV biomarker data, given evidence of persistent sex disparities in HIV diagnosis and treatment engagement [8, 9, 11, 23]. To summarize the sociodemographic characteristics of the men, we presented unweighted *n* values and weighted percentages (including 95% CIs) in the descriptive statistics. We then estimated weighted HIV prevalences and their corresponding 95% CIs across sociodemographic subgroups. Weighted proportions of HIV status unawareness, the primary outcome of interest, were further summarized among HIV positive men by sociodemographic characteristics. Missing data were handled using a combination of approaches depending on the analysis. For descriptive analyses and prevalence, estimates were calculated using available (non-missing) observations for each variable, and denominators therefore varied across characteristics. We did a complete case analysis for our adjusted multivariable logistic regression model, restricting the analytic sample to individuals with non-missing outcome and covariate data (*n* = 785). The extent of missingness was generally low for most covariates ($\leq 3\%$), but marital status had a higher proportion of missing data (10.3%) and was interpreted with caution.

Multivariable Logistic Regression

To identify the factors associated with HIV awareness status, we fit a survey-weighted logistic regression model using the `svyglm` function from the *survey* package in R. The multivariable model was

adjusted for age, urban/rural residence, education level, household wealth quintile, and marital status. Adjusted odds ratios (aORs) and 95% confidence intervals were reported.

Geospatial analysis

To characterize the subnational geographic distribution of the HIV burden, we conducted a series of spatial analyses at the provincial and survey cluster levels. We obtained the geographic coordinates of the survey clusters from the ZIMPHIA 2020 dataset. Cluster centroids within each of the provinces were recorded using global positioning system (GPS) receivers [3]. To protect respondent confidentiality, GPS coordinates were randomly displaced prior to public release, up to 2km in urban clusters and 5km in rural clusters [3]. Therefore, cluster-level spatial findings were indicative of general geographic patterns rather than precise locations.

We generated choropleth maps to display the spatial distribution of HIV prevalence and the gaps to the 95-95-95 targets. Survey-weighted estimates were aggregated at the provincial level using administrative boundary shapefiles for Zimbabwe linked to the ZIMPHIA data.

To assess for geographic clustering of HIV prevalence and unawareness, we performed spatial autocorrelation using Global Moran's I statistic. We subsequently applied Local Indicators of Spatial Association (LISA) to identify clusters of high and low values. This allowed for the detection of hotspots (high-high clusters) and cold spots (low-low clusters). Statistical significance was assessed at a threshold of $p < 0.05$.

Ethical Considerations

This secondary analysis was conducted using publicly available de-identified data from the ZIMPHIA 2020 study; additional institutional review board approval was not required. We registered and requested the data from ICAP at Columbia University and were granted access. Ethical procedures for data collection were the responsibility of the institutions that implemented and conducted the interviews. The ZIMPHIA 2020 survey protocol was approved by the Medical Research Council of Zimbabwe (MRCZ), the institutional review boards of Columbia University Medical Center, Westat, and the United States Centers for Disease Control and Prevention (CDC). The survey was conducted in accordance with the Declaration of Helsinki and relevant national and institutional guidelines and regulations. Written informed consent was obtained from participants aged 18 or older, and written informed assent was obtained from those aged 15–17 after written informed consent was obtained from their parents or legal guardians.

Results

National HIV burden and progress toward the 95-95-95 targets

The estimated overall prevalence of HIV among adults aged 15 years or more was 12.9% (95% CI: 12.3%–13.6%); see **S1** Table 1. HIV prevalence was higher among women, 15.3% (95% CI: 14.4%–16.1%), compared to men, 10.2% (95% CI: 9.5%–11.0%). For the progress towards the 95-95-95 targets, 86.8% (95% CI: 85.3%–88.4%) of those who were HIV positive were aware of their status; among those aware of their status, 97% (95% CI: 96.2%–97.7%) were on ART and among those who were on ART, 90.3% (95% CI: 89.0%–91.6%) were virally suppressed. However, men performed more poorly than women across all the 95-95-95 targets of the HIV care continuum as depicted in Fig. 2. While 88.3% (95% CI: 86.8%–89.8%) of HIV positive women were aware of their status, only 84.3% (95% CI: 81.4%–87.2%) of the men were aware. ART coverage among those aware of their status was 97.6% (95% CI: 96.8%–98.4%) among the women, compared to 95.9% (95% CI: 94.3%–97.5%) among the men, and lastly, viral suppression among those on ART was 91.0% (95% CI: 89.6%–92.5%) for the women compared to 89.0% (95% CI: 86.6%–91.5%) for the men.

Note

Horizontal lines represent 95% confidence intervals. The dashed vertical line indicates the 95% target threshold. HIV prevalence was estimated among all tested participants. First 95 estimated among HIV-positive participants; Second 95 estimated among HIV-positive participants aware of their status; Third 95 estimated among HIV-positive participants on ART with no-missing viral load suppression status. Estimates account for the complex ZIMPHIA survey design using final blood test weights.

Figure 2. HIV prevalence and progress toward the 95–95–95 targets by gender, ZIMPHIA 2020

Primary analytic sample characteristics

Table 1 shows the weighted sociodemographic characteristics of men aged 15 years and older included in this study. A total of 7,664 men completed the interview, provided blood, and had a definitive HIV test result from the ZIMPHIA 2020 survey. Most of the men were aged 25 to 44 years (41.8%; 95% CI: 40.2%–43.3%). About 70.9% (95% CI: 69.1%–72.6%) had completed high school, and 88.3% (95% CI: 87.3%–89.4%) were married or cohabiting. Manicaland province, Mashonaland East, and Mashonaland West contributed the highest proportions of participants, at 13.7% (95% CI: 12.0%–15.4%), 13.6% (95% CI: 9.7%–17.6%), and 13.3% (95% CI: 11.7%–14.8%), respectively. The majority of the men were rural residents (70.9%; 95% CI: 67.6%–74.1%) and were not circumcised (76.9%; 95% CI: 75.6%–78.2%). Compared to the HIV negative men, those who were positive were older, attained lower levels of education, were in the lower wealth quintiles, and were less likely to be married or circumcised.

Table 1
Sample characteristics of ZIMPHIA 2020 (Zimbabwe Men aged 15 years or older)

Category	HIV Negative (n = 6,758)		HIV Positive (n = 906)		Overall (n = 7,664)	
	n	Weighted %	n	Weighted % (95% CI)	n	Weighted % (95% CI)
Age group (years)						
15–24	2446	39.5 (38.0–41.0)	64	8.6 (6.4–10.8)	2510	36.4 (35.0–37.7)
25–44	2506	41.2 (39.6–42.9)	363	46.3 (42.8–49.8)	2869	41.8 (40.2–43.3)
45+	1806	19.2 (18.2–20.3)	479	45.1 (42.1–48.2)	2285	21.9 (20.9–22.9)
Education level						
High school or higher	4380	71.6 (69.8–73.4)	531	64.1 (60.2–68.0)	4911	70.9 (69.1–72.6)
Primary school or below	2180	28.4 (26.6–30.2)	348	35.9 (32.0–39.8)	2528	29.1 (27.4–30.9)
Wealth quintile						
Lowest	1722	21.6 (19.2–24.0)	254	23.7 (20.2–27.2)	1976	21.8 (19.5–24.2)
Second	1581	21.8 (19.9–23.6)	209	21.9 (18.9–25.0)	1790	21.8 (20.0–23.6)
Middle	1355	20.4 (18.4–22.3)	183	21.9 (18.1–25.7)	1538	20.5 (18.6–22.5)
Fourth	970	17.9 (15.6–20.2)	142	18.0 (14.7–21.2)	1112	17.9 (15.8–20.0)
Highest	1130	18.3 (16.3–20.3)	118	14.5 (11.1–17.9)	1248	17.9 (16.0–19.8)
Marital status						
Married/Cohabiting	3720	89.3 (88.3–90.4)	671	82.6 (79.9–85.2)	4391	88.3 (87.3–89.4)
Widowed	103	1.7 (1.3–2.0)	54	5.9 (4.1–7.6)	157	2.3 (1.9–2.7)
Divorced/Separated/Single	364	9.0 (8.0–10.0)	88	11.6 (8.9–14.2)	452	9.4 (8.4–10.3)
Province						

Category	HIV Negative (n = 6,758)		HIV Positive (n = 906)		Overall (n = 7,664)	
	n	Weighted %	n	Weighted % (95% CI)	n	Weighted % (95% CI)
Age group (years)						
Bulawayo	532	5.3 (4.6–6.0)	78	5.6 (4.1–7.1)	610	5.3 (4.6–6.1)
Manicaland	814	14.1 (12.3–15.9)	77	10.3 (8.1–12.4)	891	13.7 (12.0–15.4)
Mashonaland Central	822	9.9 (8.7–11.1)	107	10.2 (7.7–12.7)	929	9.9 (8.7–11.1)
Mashonaland East	647	13.6 (9.8–17.5)	82	13.6 (8.1–19.0)	729	13.6 (9.7–17.6)
Mashonaland West	894	13.4 (11.7–15.0)	103	12.3 (9.3–15.4)	997	13.3 (11.7–14.8)
Matabeleland North	581	5.4 (4.8–6.0)	97	6.8 (5.4–8.2)	678	5.6 (5.0–6.2)
Matabeleland South	552	5.3 (4.4–6.1)	93	6.6 (4.9–8.3)	645	5.4 (4.5–6.3)
Midlands	749	11.2 (9.7–12.7)	107	12.2 (10.1–14.3)	856	11.3 (9.9–12.7)
Masvingo	722	10.1 (8.7–11.4)	99	10.3 (7.1–13.5)	821	10.1 (8.7–11.5)
Harare	445	11.8 (9.2–14.3)	63	12.1 (8.5–15.7)	508	11.8 (9.3–14.3)
Circumcision status						
Not Circumcised	5060	75.5 (74.1–76.9)	803	89.1 (86.9–91.4)	5863	76.9 (75.6–78.2)
Circumcised	1686	24.5 (23.1–25.9)	102	10.9 (8.6–13.1)	1788	23.1 (21.8–24.4)
Residence						
Urban	1661	29.2 (25.9–32.5)	224	28.7 (24.1–33.2)	1885	29.1 (25.9–32.4)
Rural	5097	70.8 (67.5–74.1)	682	71.3 (66.8–75.9)	5779	70.9 (67.6–74.1)

Distribution of HIV prevalence among men

Table 2 shows the weighted distribution of HIV prevalence among men across sociodemographic characteristics. The prevalence of HIV among men aged 45 + years (21.1%; 95% CI: 19.1%–23.2%) was almost twice that among those 25 to 44 years (11.3%; 95% CI: 10.2%–12.6%) and more than 9 times that among those aged 15 to 24 years (2.4%; 95% CI: 1.9%–3.1%). HIV prevalence declined with higher educational attainment, from 12.6% (95% CI: 11.3%–14.0%) among men with primary education or below to 9.2% (95% CI: 8.4%–10.2%) among those with high school or above. The prevalence across the wealth quintiles was fairly similar, but was lowest in the highest wealth quintile (8.3%; 95% CI: 6.5%–10.4%) and highest in the lowest wealth quintile (11.1%; 95% CI: 9.6%–12.8%). HIV prevalence was highest among men who were widowed (37.7%; 95% CI: 29.3%–46.9%). Those who were not circumcised had more than twice the prevalence of HIV (11.9%; 95% CI: 10.9%–12.9%) compared to those who were circumcised (4.8%; 95% CI: 3.9%–5.9%). In terms of geographical locations, HIV prevalence among men was highest in the southern and western provinces of Matabeleland North (12.5%; 95% CI: 10.2%–15.1%) and Matabeleland South (12.5%; 95% CI: 10.2%–15.2%), and lowest in the eastern Manicaland province (7.7%; 95% CI: 6.0%–9.7%). There was little difference in prevalence between urban (10.1%; 95% CI: 8.8%–11.5%) and rural participants (10.3%; 95% CI: 9.4%–11.3%).

Table 2
Distribution of HIV prevalence among men

Characteristic	Total (n = 7664)	HIV positive (n = 906)	Weighted HIV prevalence % (95% CI)
Age group (years)			
15–24	2510	64	2.4 (1.9% – 3.1)
25–44	2869	363	11.3 (10.2–12.6)
45+	2285	479	21.1 (19.1–23.2)
Education level			
Primary school or below	2528	348	12.6 (11.3–14.0)
High school or higher	4911	531	9.2 (8.4–10.2)
Wealth quintile			
Lowest	1976	254	11.1 (9.6–12.8)
Second	1790	209	10.3 (9.0–11.8)
Middle	1538	183	10.9 (9.3–12.8)
Fourth	1112	142	10.3 (8.4–12.5)
Highest	1248	118	8.3 (6.5–10.4)
Marital status			
Married/Cohabiting	4391	671	13.7 (12.6–15.0)
Widowed	157	54	37.7 (29.3–46.9)
Divorced/Separated/Single	452	88	18.1 (14.6–22.3)
Province			
Bulawayo	610	78	10.8 (8.8–13.1)
Manicaland	891	77	7.7 (6.0–9.7)
Mashonaland Central	929	107	10.5 (8.4–13.1)
Mashonaland East	729	82	10.2 (8.0–12.8)
Mashonaland West	997	103	9.5 (7.2–12.5)
Matabeleland North	678	97	12.5 (10.2–15.1)
Matabeleland South	645	93	12.5 (10.2–15.2)
Midlands	856	107	11.1 (9.1–13.4)

Characteristic	Total (n = 7664)	HIV positive (n = 906)	Weighted HIV prevalence % (95% CI)
Age group (years)			
Masvingo	821	99	10.5 (8.1–13.5)
Harare	508	63	10.5 (7.9–13.8)
Circumcision status			
Not Circumcised	5863	803	11.9 (10.9–12.9)
Circumcised	1788	102	4.8 (3.9–5.9)
Residence			
Urban	1885	224	10.1 (8.8–11.5)
Rural	5779	682	10.3 (9.4–11.3)

Prevalence of HIV status unawareness among HIV-Positive men within each sociodemographic group

Table 3 shows the weighted proportions of HIV status unawareness among men living with HIV within each sociodemographic group. The prevalence of unawareness was much higher among younger men aged 15–24 years, 28.1% (95% CI: 15.7%–45.0%), nearly four times the proportion observed among men aged 45 years and older, 7.7% (95% CI: 5.2%–11.3%). The gaps in HIV diagnosis were fairly similar across education levels. Those who had attained primary and below education had a prevalence of 15.5% (95% CI: 11.5%–20.6%), while those who had attained secondary and above education had a prevalence of 15.8% (95% CI: 12.6%–19.8%). There were subtle differences across wealth quintiles, but those in higher quintiles had higher proportions of unawareness, 17.0% (95% CI: 9.5%–28.7%) in the highest quintile versus 14.6% (95% CI: 10.2%–20.6%) in the lowest quintile. Compared to those who were not circumcised, 16.1% (95% CI: 13.3%–19.5%), the circumcised 12.1% (95% CI: 5.6%–23.9%) had a slightly lower proportion of HIV status unawareness. There were geographical differences in HIV status unawareness. The lowest proportions were observed in Mashonaland East (8.4%; 95% CI: 3.4%–19.3%) and Matabeleland South (9.3%; 95% CI: 4.5%–18.0%), both lower than the national average for men (15.7%). On the other hand, unawareness was highest in Masvingo, at 21.9% (95% CI: 13.5%–33.5%), and in Mashonaland Central, at 26.4% (95% CI: 16.6%–39.2%), both of which were much higher than the national average. Proportions of HIV unawareness were fairly similar among urban and rural residents, 17.2% (95% CI: 11.4%–25.0%) and 15.1% (95% CI: 12.2%–18.5%), respectively.

Table 3

Proportions of HIV status unawareness among men living with HIV sociodemographic characteristics, ZIMPHIA 2020 (n = 906)

Characteristic	HIV Positive (n = 906)	Unaware (n = 129)	Weighted % (95% CI)
Age group (years)			
15–24	64	18	28.1 (15.7–45.0)
25–44	363	76	21.1 (16.8–26.2)
45+	479	35	7.7 (5.2–11.3)
Education level			
Primary school or below	348	47	15.5 (11.5–20.6)
High school or higher	531	79	15.8 (12.6–19.8)
Wealth quintile			
Lowest	254	32	14.6 (10.2–20.6)
Second	209	27	14.5 (9.9–20.8)
Middle	183	31	16.4 (11.1–23.6)
Fourth	142	21	16.5 (10.1–25.8)
Highest	118	18	7.0 (9.5–28.7)
Marital status			
Married/Cohabiting	671	90	14.4 (11.6–17.8)
Widowed	54	3	9.4 (1.1–48.7)
Divorced/Separated/Single	88	15	18.1 (9.5–31.7)
Province			
Bulawayo	78	12	16.0 (8.0–29.3)
Manicaland	77	7	11.4 (5.5–22.2)
Mashonaland Central	107	26	26.4 (16.6–39.2)
Mashonaland East	82	7	8.4 (3.4–19.3)
Mashonaland West	103	16	17.7 (11.3–26.8)
Notes: HIV status unawareness estimates are weighted using survey sampling weights from ZIMPHIA 2020. Percentages are calculated within categories. Estimates are based on non-missing observations for each variable; therefore, denominators may vary across characteristics.			

Characteristic	HIV Positive (n = 906)	Unaware (n = 129)	Weighted % (95% CI)
Age group (years)			
Matabeleland North	97	9	10.7 (4.6–23.3)
Matabeleland South	93	8	9.3 (4.5–18.0)
Midlands	107	16	16.1 (10.2–24.4)
Masvingo	99	19	21.9 (13.5–33.5)
Harare	63	9	16.7 (7.1–34.3)
Circumcision status			
Not Circumcised	803	119	16.1 (13.3–19.5)
Circumcised	102	10	12.1 (5.6–23.9)
Residence			
Urban	224	35	17.2 (11.4–25.0)
Rural	682	94	15.1 (12.2–18.5)
Notes: HIV status unawareness estimates are weighted using survey sampling weights from ZIMPHIA 2020. Percentages are calculated within categories. Estimates are based on non-missing observations for each variable; therefore, denominators may vary across characteristics.			

Assessment of factors associated with HIV status awareness

Survey-weighted logistic regression analysis was used to examine the factors associated with HIV status unawareness among men living with HIV, as shown in Table 4. Age was significantly associated with HIV status unawareness in both the unadjusted and adjusted models. When the covariates were held constant, there was a 9% decrease in the odds of HIV status unawareness with each additional year in age (adjusted OR = 0.91; 95% CI: 0.88–0.94; $p < 0.001$). No statistically significant associations were observed between education, wealth quintile, marital status, circumcision status, or place of residence in both the unadjusted and adjusted models.

Table 4

Factors associated with HIV status awareness among men living with HIV: logistic regression analysis, ZIMPHIA 2020

Table 4: Logistic Regression of Unawareness of HIV-Positive Status Among Men Living with HIV, ZIMPHIA 2020		
1st 95: Unawareness of HIV-positive status		
Characteristic¹	Model 1: Unadjusted OR [95% CI]¹	Model 2: Adjusted OR [95% CI]¹
Age	0.91 [0.89–0.94] *	0.91 [0.88–0.94] *
Educational attainment		
High school or higher	Reference	Reference
Primary school or below	0.87 [0.56–1.35]	0.90 [0.56–1.46]
Residence		
Urban	Reference	Reference
Rural	0.89 [0.50–1.57]	1.09 [0.48–2.48]
Wealth quintile		
Highest	Reference	Reference
Fourth	0.99 [0.38–2.60]	0.78 [0.28–2.18]
Middle	0.99 [0.44–2.22]	0.81 [0.29–2.24]
Second	0.79 [0.34–1.84]	0.66 [0.22–1.94]
Lowest	0.76 [0.33–1.79]	0.61 [0.20–1.86]
Marital status		
Married/Cohabiting	Reference	Reference
Widowed	0.62 [0.16–2.45]	1.22 [0.31–4.84]
Divorced/Separated/Single	1.33 [0.70–2.53]	1.05 [0.54–2.05]
Circumcision status		
¹ Notes: * p < 0.001. Estimates are based on survey-weighted logistic regression models among men living with HIV in ZIMPHIA 2020. Model 1 shows unadjusted odds ratios from separate models for each covariate. Model 2 presents adjusted odds ratios from a multivariable model including age group, residence, educational attainment, wealth quintile, marital status, and circumcision status. The analytic sample was restricted to men living with HIV with no missing awareness outcome and complete covariate data. The final analytic sample size for the multivariable model was N = 785.		
Abbreviations: CI = Confidence Interval, OR = Odds Ratio		

Table 4: Logistic Regression of Unawareness of HIV-Positive Status Among Men Living with HIV, ZIMPHIA 2020		
Not Circumcised	Reference	Reference
Circumcised	1.02 [0.47–2.22]	1.02 [0.48–2.21]
¹ Notes: * $p < 0.001$. Estimates are based on survey-weighted logistic regression models among men living with HIV in ZIMPHIA 2020. Model 1 shows unadjusted odds ratios from separate models for each covariate. Model 2 presents adjusted odds ratios from a multivariable model including age group, residence, educational attainment, wealth quintile, marital status, and circumcision status. The analytic sample was restricted to men living with HIV with no missing awareness outcome and complete covariate data. The final analytic sample size for the multivariable model was $N = 785$.		
Abbreviations: CI = Confidence Interval, OR = Odds Ratio		

Geospatial Analysis

Given the observed geographic variation in HIV status unawareness estimates across provinces, spatial patterns were further explored using geospatial mapping and hotspot analysis. Figure 2 presents the geographic distribution of HIV prevalence and gaps in progress towards the 95–95–95 targets among men in Zimbabwe using ZIMPHIA 2020 data. HIV prevalence was highest among men in the southern, central, and western provinces (Matabeleland provinces and Midlands), with comparatively lower prevalence in the northern and eastern provinces. In contrast, gaps in the first 95 (HIV status awareness) were more pronounced in the northern and north-eastern provinces (Mashonaland West and Mashonaland Central) and in the south-eastern province of Masvingo. Gaps in the second 95 (ART coverage) were minimal across the country, with only slightly higher gaps observed in Harare and Midlands. However, gaps in the third 95 (viral suppression) were more pronounced in the northern and eastern provinces, with Manicaland recording the highest gap despite having one of the lowest HIV prevalence levels overall.

Note

Province abbreviations: BU: Bulawayo; HA: Harare; MA: Manicaland; MC: Mashonaland Central; ME: Mashonaland East; MW: Mashonaland West; MV: Masvingo; MN: Matabeleland North; MS: Matabeleland South; MI: Midlands.

Spatial Autocorrelation and Hotspot Analysis

Figure 3 shows the global spatial autocorrelation and Local Indicators of Spatial Association (LISA) results for HIV prevalence among men. The Moran scatterplot illustrates the relationship between cluster-level HIV prevalence and the spatially lagged values of the five nearest neighboring clusters. For HIV prevalence, we found a positive spatial autocorrelation (Moran's $I = 0.087$, $p = 0.005$) showing a tendency for clustering of values in space. LISA analysis identified statistically significant local clusters ($p < 0.05$). The cluster map shows high–high clusters of HIV prevalence (hotspots) in the regions of Matabeleland North and Matabeleland South, and in parts of the southern Midlands province, indicating

localized areas of high HIV burden. We did not find statistically significant global spatial autocorrelation in awareness of HIV-positive status among men (Moran's $I = 0.104$, $p = 0.067$), Fig. 4.

Discussion

In this study, we provide a comprehensive analysis of HIV prevalence and the progress towards the UNAIDS 95-95-95 targets among Zimbabwean men, using the population-based ZIMPHIA 2020 data. We contribute to the literature by examining male-specific HIV gaps and exploring variations at the subnational level in Zimbabwe. Our main focus was to understand subnational distributions of HIV prevalence and gaps in HIV diagnosis, as well as the factors associated with HIV underdiagnosis. This study intends to support targeted and efficient allocation of HIV resources.

Although HIV prevalence was lower among men compared to women (10.2% vs 15.3%), men performed worse across all cascade targets (84.3% vs. 88.3% aware, 95.9% vs. 97.6% on ART, and 89% vs. 91% virally suppressed). The largest gap was in HIV diagnosis, with a much higher proportion of men (11.7%) than women (5.7%) unaware of their HIV-positive status. Similar trends have been observed across a number of sub-Saharan African countries, including Eswatini, Mozambique, Malawi, Tanzania, and Uganda [17, 23, 25]. Earlier data from Zimbabwe also identified being male as a predictor of being unaware of an HIV positive status [26]. HIV positive men are more likely to be unaware of their status and thus have a higher likelihood of presenting with advanced HIV disease, resulting in poorer clinical outcomes [7]. Although this disparity is often attributed to gender norms (e.g., compromised masculinity associated with health care seeking) [9, 10, 14], structural factors within the health system also play an important role [6, 12]. Health systems in low-and middle-income countries (LMICs) have traditionally been more focused on maternal and child health, resulting in more established service delivery for women and children, including antenatal care, cervical cancer screening, and immunization services [12, 27–29]. VMCC, a key HIV prevention program, remains a major entry point for men and should be prioritized as an opportunity to increase HIV diagnosis among men [7, 30–36]. Our findings indicated that men who were not circumcised had more than twice the prevalence of HIV compared to circumcised men and had higher proportions of unawareness. Several randomized controlled trials conducted in Africa also show that circumcision reduces the risk of acquiring HIV through heterosexual sex by approximately 60% [32, 34, 35].

Our study noted an inverse relationship between prevalence and unawareness across several demographic characteristics, whereby those with lower prevalence tended to have higher levels of HIV status unawareness. Although younger men aged 15–24 years had lower HIV prevalence, their gap in diagnosis was almost 4 times higher than that of older men. Similarly, those in the highest wealth quintile and those who were married had a lower prevalence of HIV compared to other groups, but had higher proportions of HIV status unawareness. Age had a statistically significant association with HIV status unawareness. Each additional year of age was associated with a 9% decrease in the odds of unawareness. The pattern contradicts patterns observed in higher-income countries such as the U.S [37, 38], but is corroborated by findings from other studies from LMICs [11, 25, 39, 40]. A multi-country

analysis of data from nationally representative surveys across seven countries: Eswatini, Lesotho, Malawi, Mozambique, Tanzania, Uganda, and Zimbabwe, presented at the Conference on Retroviruses and Opportunistic Infections (CROI 2026) indicated that 29% of men aged 15–24 were unaware of their status [41]. Factors that have contributed to this gap include lower perceived risk, fewer interactions with the healthcare system, work-related mobility, and lack of youth-friendly services and gender norms discouraging health-seeking behavior [9, 11, 14, 41]. HIV testing strategies should prioritize populations with high levels of undiagnosed infection, even if overall prevalence is lower. Useful approaches could include expanding youth-friendly and male-centered testing approaches such as community-based self-testing, mobile outreach, and integration of HIV services in non-traditional platforms.

Our geospatial findings also indicated a spatial mismatch between HIV prevalence and unawareness, with possible programmatic implications. All three provinces in the southern and western Matabeleland regions, as well as the Midlands province, had disproportionately higher HIV prevalence. This is consistent with geospatial analysis from earlier ZIMPHIA data [42, 43]. However, gaps in HIV diagnosis were more pronounced in northern and eastern provinces such as Mashonaland Central and Masvingo. Spatial autocorrelation and hotspot analyses provided further insight into these patterns. We observed significant global spatial clustering of HIV prevalence, with localized hotspots concentrated in the Matabeleland regions and parts of the Midlands, indicating geographically concentrated areas of elevated HIV burden. In contrast, there was no evidence of significant spatial clustering in HIV status unawareness, suggesting that gaps in diagnosis are more diffusely distributed and may be driven by individual-level or health system factors rather than geographic proximity. Some potential explanations for these findings include migration patterns and differences in awareness gaps among various socioeconomic and individual-level characteristics, and differences in program investment and the HIV epidemic development between provinces. Migration patterns may facilitate the sustained, spatial clustering of high HIV prevalence in the Matabeleland provinces, where well-established migration corridors bring individuals into contact with high prevalence in neighboring South Africa and Botswana [44]. However, individual-level barriers to HIV testing, such as stigma, low treatment optimism, and distance to HIV testing facilities, may be uniformly distributed across the provinces rather than geographically concentrated [45, 46]. Together, these findings highlight the importance of combining spatial and sociodemographic analyses to better understand the distribution of HIV burden and service gaps.

Strengths and Limitations

Our study was not without limitations. The ZIMPHIA 2020 was a cross-sectional survey, therefore limiting causal inference. The relationships between sociodemographic characteristics and HIV unawareness could not be interpreted as causal. In addition, the data we used were collected between 2019 and 2020 and may not represent the current status of the HIV program in Zimbabwe. Lastly, we conducted geospatial analysis at the cluster level, and some estimates may be unstable due to the small sample size. Therefore, these findings should be interpreted as indicative of spatial patterns rather than precise local estimates. Notwithstanding these limitations, this study used the population-based

ZIMPHIA 2020 study, which is nationally representative and generalizable to the whole population of Zimbabwe. Although the data were collected between 2019 and 2020, they are still the most recent nationally representative and biomarker-confirmed estimates from Zimbabwe. The ZIMPHIA survey used laboratory-confirmed tests to determine the 95-95-95 targets, thus significantly reducing misclassification. The study included subnational geospatial analysis, providing important insights into geographic differences in HIV prevalence and diagnostic gaps, enabling the identification of priority areas that may be masked in national-level estimates. Additionally, our study focused on men, a group that is understudied and has consistently lagged in HIV testing and treatment, thereby addressing a critical gap in the literature.

Our study findings have implications for resource distribution in HIV program planning, by highlighting priority populations and geographic areas for intervention. The findings are particularly useful given the current climate of reduced external funding. Our sociodemographic differences in levels of unawareness highlight the need for male-centered, youth-friendly testing programs. Our geospatial analyses provide a roadmap for efficient allocation of resources. The Matabeleland and Midlands provinces should be prioritized for treatment scale-up and viral suppression support. On the other hand, Mashonaland Central and Masvingo need intensified investment in male-targeted HIV testing.

Conclusion

This study identified gaps in the HIV care continuum, together with sociodemographic and geographic differences in HIV prevalence and unawareness among men. Men continue to lag behind women at every stage of the HIV care cascade, with the largest gap in diagnosis. Age was significantly associated with HIV status unawareness. Younger men had higher odds of HIV status unawareness, although they had a comparably lower prevalence of HIV. Our geospatial analyses reveal a spatial mismatch between HIV burden and diagnosis gaps. While HIV prevalence was highest in the southern and western provinces, gaps in diagnosis were most pronounced in the northern and eastern provinces. This mismatch highlights the inadequacy of burden-based resource allocation alone and calls for a dual-track approach that simultaneously targets treatment scale-up in high-prevalence areas and testing intensification in areas with high undiagnosed HIV.

Abbreviations

UNAIDS

Joint United Nations Programme on HIV/AIDS

HIV

Human Immunodeficiency Virus

AIDS

Acquired Immunodeficiency Syndrome

ART

Antiretroviral Therapy

PLWHIV
People Living with HIV
ZIMPHIA
Zimbabwe Population-based HIV Impact Assessment
MoHCC
Ministry of Health and Child Care
EA
Enumeration Area
LISA
Local Indicators of Spatial Association
LMICs
Low- and Middle-Income Countries
GPS
Global Positioning System
VMCC
Voluntary Medical Male Circumcision

Declarations

Ethics approval and consent to participate

This study used secondary de-identified data from the Zimbabwe Population-based HIV Impact Assessment (ZIMPHIA) 2020, accessed with permission from ICAP at Columbia. There was no need for additional participant authorization or Institutional Review Board approval. The ZIMPHIA 2020 survey protocol was approved by the institutional review boards of Columbia University Medical Center, Westat, and the United States Centers for Disease Control and Prevention (CDC). The study was conducted in accordance with the Declaration of Helsinki and relevant guidelines and regulations. Written informed consent was obtained from participants aged 18 or older, and written informed assent was obtained from those aged 15-17 after written informed consent was obtained from their parents or legal guardians.

Consent for publication

Not Applicable

Data availability

The data that support the findings of this study are available from the Population-based HIV Impact Assessment (PHIA) Project through ICAP at Columbia University, but restrictions apply to the availability of these data, which were used under license for the current study, and so are not publicly available. Data are however available from the authors upon reasonable request and with permission of the PHIA Project. Data may be requested directly from the PHIA Data Portal at:

Competing interests

The authors declare no competing interests.

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Authors' contributions

EDM: Conceptualization of the study. EDM, EWNC, EN, PK, RK, RDA, and BFB: study methodology, design, drafting of the manuscript, manuscript writing, reviewing, and editing. EDM: ZIMPHIA Data request and acquisition. EN and RK: Introduction section draft. EDM: Method section draft. BFB and EDM: Data management and Data analysis. EDM and PK: Results section draft. EWNC and EDM: Discussion section draft. All the authors contributed equally to the study's design, review, editing, and approval of the final manuscript.

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Figures

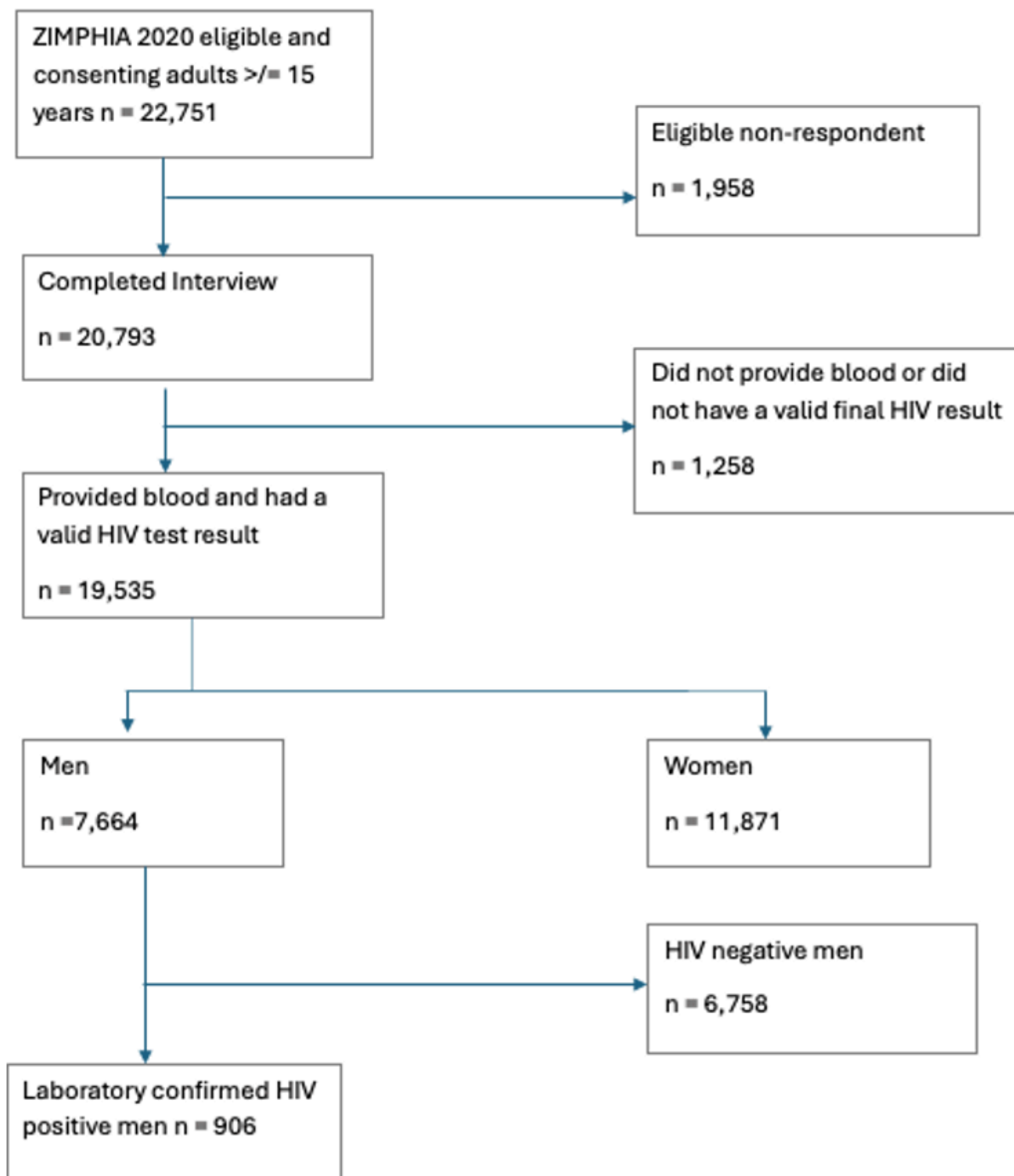


Figure 1

Flowchart of the analytic sample for the study

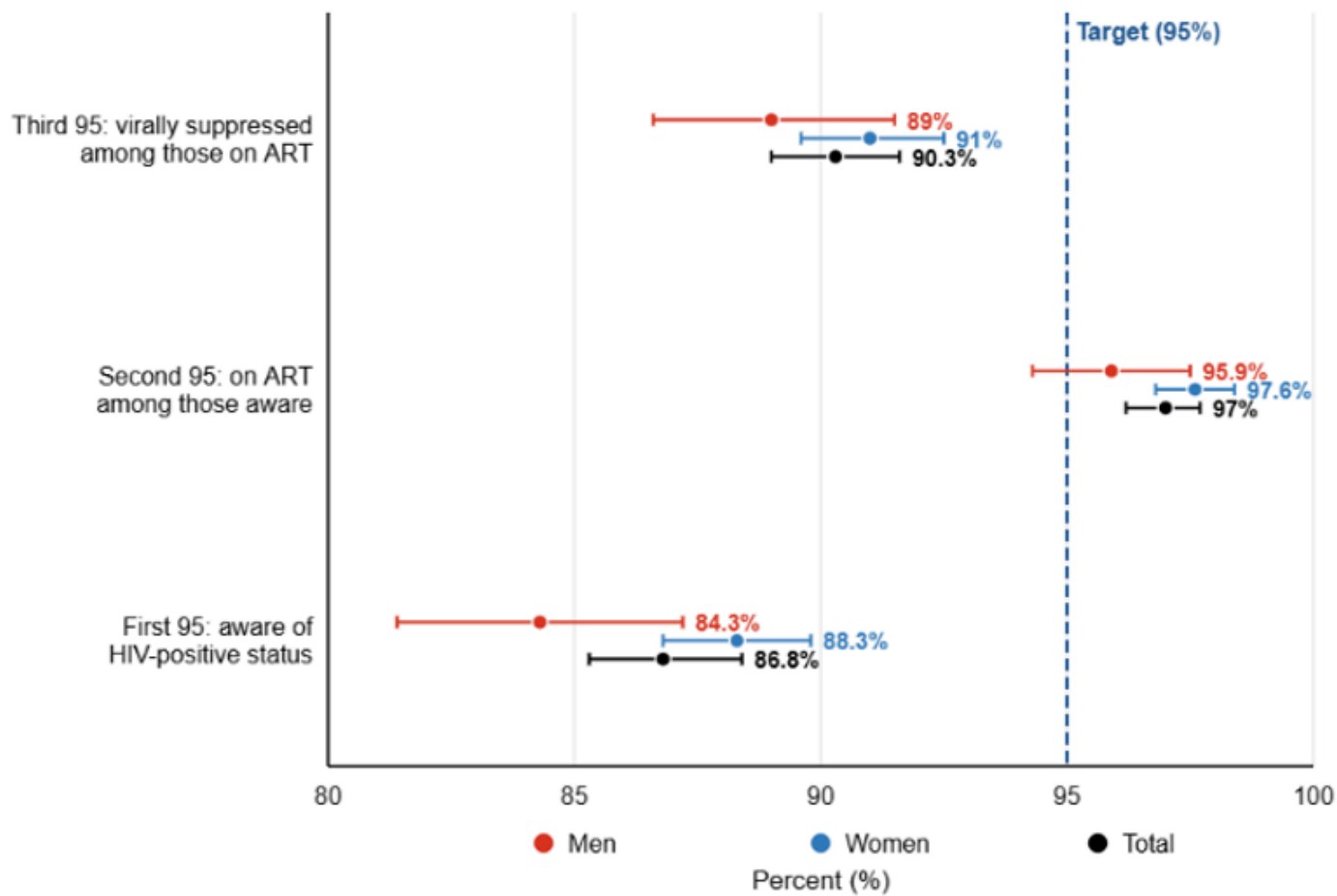


Figure 2

HIV prevalence and progress toward the 95–95–95 targets by gender, ZIMPHIA 2020

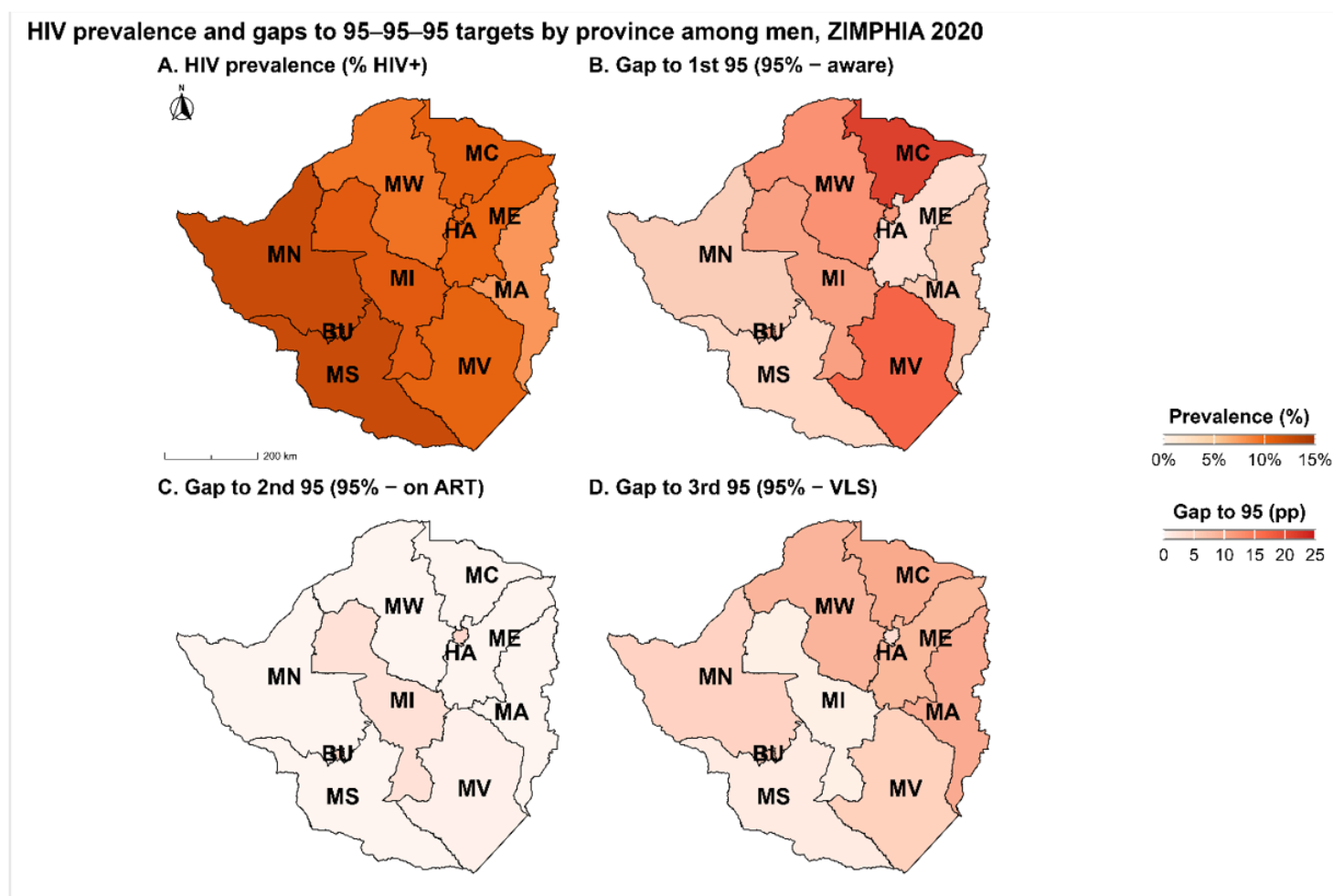


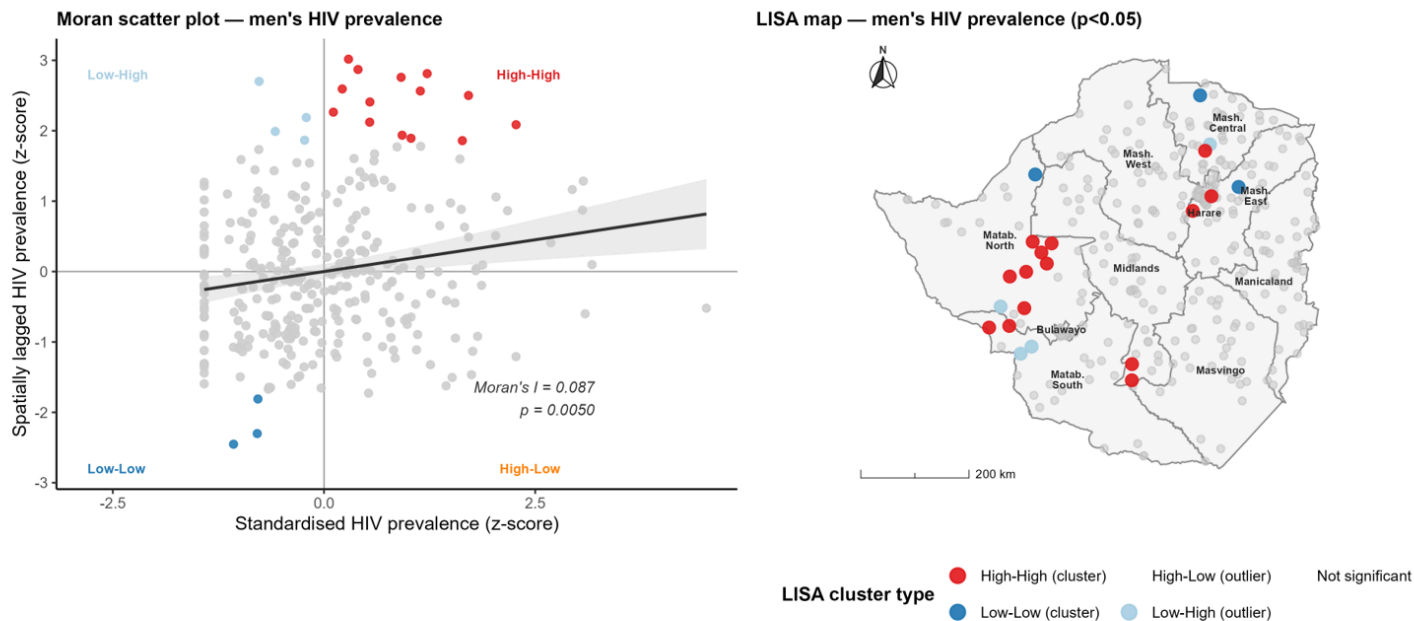
Figure 3

Fig. 2. HIV prevalence and gaps in progress toward 95-95-95 targets by province among men (ZIMPHIA 2020)

Note: Province abbreviations: BU: Bulawayo; HA: Harare; MA: Manicaland; MC: Mashonaland Central; ME: Mashonaland East; MW: Mashonaland West; MV: Masvingo; MN: Matabeleland North; MS: Matabeleland South; MI: Midlands.

Spatial autocorrelation in men's HIV prevalence — ZIMPHIA 2020

Left: Moran scatter ($I=0.087$, $p=0.0050$). Right: LISA map with significant local clusters ($p<0.05$).



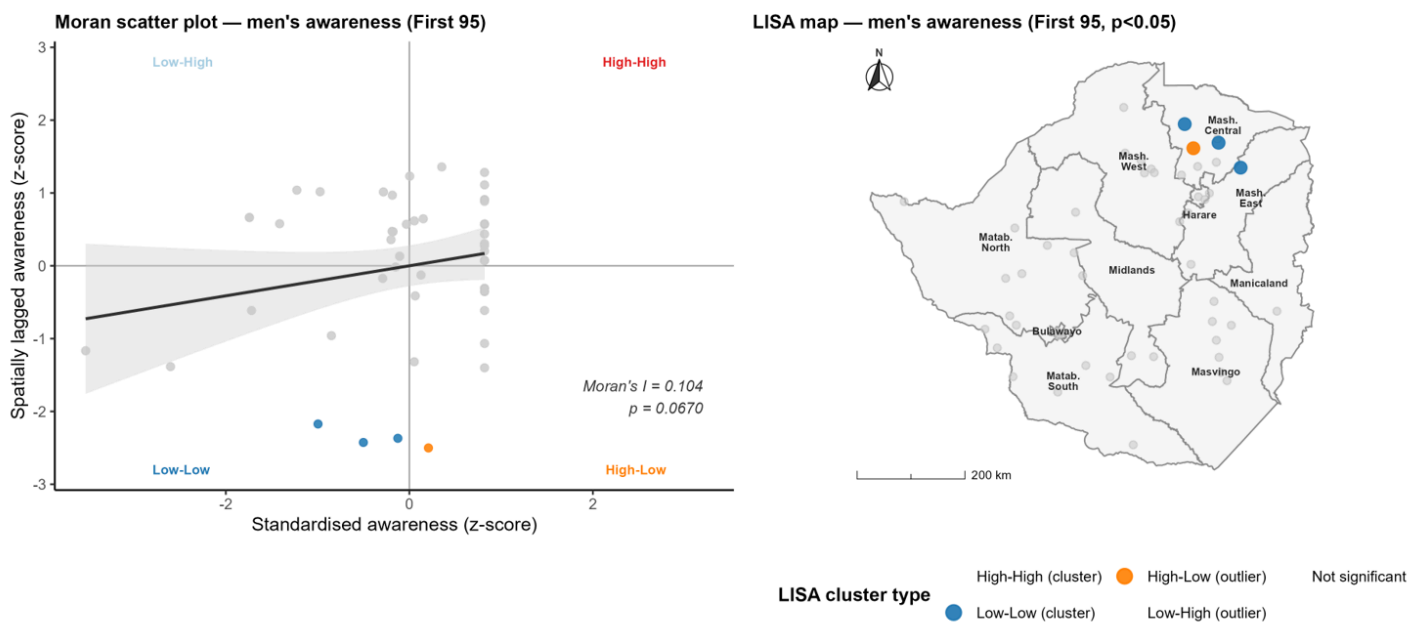
Analysis restricted to MEN ONLY; $k=5$ nearest-neighbour weights (row-standardised). LISA p -values not corrected for multiple comparisons.

Figure 4

Fig 3. Global spatial autocorrelation (Moran's I) and local clustering (LISA) of HIV prevalence among men in Zimbabwe, ZIMPHIA 2020

Spatial autocorrelation in men's awareness of HIV status (First 95) — ZIMPHIA 2020

Left: Moran scatter ($I=0.104$, $p=0.0670$). Right: LISA map with significant local clusters ($p<0.05$).



Analysis restricted to HIV-POSITIVE MEN ONLY; $k=5$ nearest-neighbour weights (row-standardised). LISA p -values not corrected for multiple comparisons.

Figure 5

Fig 4. Global spatial autocorrelation (Moran's I) and local clustering (LISA) of HIV unawareness among men in Zimbabwe, ZIMPHIA 2020

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- [Appendix.docx](#)