

# Prevalence and Determinants of HIV Among Women Aged 15–49 Years in Zambia: A Multilevel Mixed-Effects Analysis

**Mahmud Hossen**

Jagannath University

**Md Rafi Hasan**

Shahjalal University of Science and Technology

**Md Sabbir Hosain**

**bmsabbirhossainsakib@gmail.com**

Shahjalal University of Science and Technology

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## Research Article

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# Abstract

## Background

HIV remains a major public health concern in sub-Saharan Africa, particularly among women due to biological and socioeconomic vulnerabilities. However, updated national evidence on HIV prevalence and its determinants among women in Zambia remains limited. This study aimed to estimate the prevalence and identify factors associated with HIV among women using the most recent Zambia Demographic and Health Survey (ZDHS) 2024.

## Methods

A cross-sectional analytical study was conducted using nationally representative data from the ZDHS 2024. A total of 11,542 women aged 15–49 years with valid HIV test results were included. Weighted descriptive statistics were used to estimate HIV prevalence. Bivariate analysis using the chi-square test assessed associations between HIV status and explanatory variables. A multilevel mixed-effects logistic regression model was employed to identify factors associated with HIV infection. Adjusted odds ratios (AORs) with 95% confidence intervals (CIs) were reported.

## Results

The study shows that approximately one in every ten women (9.33%) in the studied population of reproductive-age women in Zambia is living with HIV. HIV prevalence was higher among urban residents, women from wealthier households, and those in Western and Lusaka provinces. Multilevel analysis showed that rural residence was associated with lower odds of HIV (AOR = 0.60), while higher education was protective (AOR = 0.33). Behavioral factors were strong predictors, with increasing odds of HIV among women with multiple sexual partners, particularly those with six or more partners (AOR = 7.40). Women reporting recent sexually transmitted infections had higher odds of HIV (AOR = 1.53). Frequent health facility visits were associated with reduced odds (AOR = 0.65). Additionally, women from higher wealth quintiles had significantly increased odds of HIV, and notable regional disparities were observed.

## Conclusion

HIV among women in Zambia is influenced by a combination of socioeconomic, behavioral, and geographic factors. Targeted interventions focusing on high-risk groups, including urban residents and women with multiple sexual partners, alongside strengthening education and healthcare access, are essential to reduce HIV burden and achieve national HIV control targets.

## Introduction

HIV belongs to the Lentivirus genus, which is part of the Retroviridae family and Orthoretrovirinae subfamily. HIV is categorized into two categories based on genetic traits and viral antigen differences (HIV-1 and HIV-2) [1]. A persistent HIV infection leads to acquired immune deficiency syndrome (AIDS). The official commencement of the pandemic came in the summer of 1981 when the US Centers for Disease Control and Prevention (CDC) reported on a cluster of *Pneumocystis carinii* pneumonia (PCP) in five homosexual men [2].

Viruses, particularly retroviruses, reproduce by entering host cells and creating new viruses. Retroviruses, a broad group of RNA viruses, need a DNA intermediary to replicate. Key historical developments in retrovirus research include the discovery of the equine infectious anemia virus in 1904 and the identification of HIV-1 as the cause of AIDS in 1983–1984. These viruses, which reverse the genetic information flow from DNA to RNA, are classified into three types: oncoviruses, lentiviruses, and spumaviruses. Retroviral replication entails the virion entering the host cell, reverse transcription of RNA to DNA, and integration into the host genome, which is facilitated by key genes *gag*, *pol*, and *env* located within long terminal repeats (LTRs) [3, 4].

In Asia and the Pacific, 6.90 million people live with HIV, with a concentration on males who have sex with men and drug addicts. The Middle East and North Africa have modest incidence rates; however Eastern Europe and Central Asia are experiencing an increase in infections caused mostly by injectable drug use. Western and Central Europe, as well as North America, have low HIV prevalence, however it is concentrated in specific populations. across 2023, around 39 million people were living with HIV, primarily impacting women and teenage girls across Africa, with Zambia having a notably high prevalence, indicating regional differences [5].

Due to biological vulnerability, socioeconomic inequality, gender power disparities, and restricted access to healthcare facilities, women in sub-Saharan Africa are more likely to contract HIV. HIV transmission among women is greatly influenced by characteristics such early sexual debut, multiple sexual partnerships, sexually transmitted infections (STIs), and inadequate access to preventative programs, according to earlier research [3, 4]. Another study investigates the relationship between schooling status and HIV infection in women aged 15 to 19 in nine DREAMS countries in Eastern and Southern Africa. It discovered that currently attending school relates to a lower risk of HIV infection in Lesotho, Eswatini, Uganda, and Zambia, but not in Kenya, Malawi, Mozambique, Tanzania, and Zimbabwe [6].

In 2024, over 40.80 million individuals worldwide were living with HIV, with women and girls accounting for 53%. There were around 1.3 million new infections and 630,000 AIDS-related deaths, largely in Sub-Saharan Africa, where half of all HIV-positive persons live, with adolescent girls and women being most vulnerable [7]. A 3.5-year follow-up study in rural South Africa found that young women aged 13–23 who attended school less than 80% of the time had a cumulative HIV incidence of 19.90%. Similarly, 38.50% of this group had herpes simplex virus type 2 (HSV-2) at the conclusion of the follow-up, compared to 17.31% of those who attended more frequently. The findings indicated a higher weighted hazard for both HIV and HSV-2 infections in young women who attended less school or dropped out, which is consistent

with previous research from South Africa and Zimbabwe that found significantly higher odds of infection for out-of-school young women than their in-school peers [8].

HIV prevalence in African countries is influenced by behavioral and socioeconomic factors, and GIS and spatial analysis can identify high-risk locations for targeted interventions.[9] Zambia is in Southern Africa and covers 752,612 square kilometers. The present population is estimated at 13 million, with an annual growth rate of 2.80. Approximately 39% of the population lives in urban areas. Approximately two-thirds of the population are under the age of 25, with 22% falling between 15 and 24. HIV prevalence is 13.30% among individuals aged 15–49, and 6.60% among young people aged 15–24 years [10]. Zambia has a large HIV burden, with almost 1.4 million people living with the virus and an adult prevalence of 10.8% as of 2022. Despite progress in prevention and treatment, as indicated by 33,000 new infections and 19,000 AIDS-related deaths every year, significant problems persist. Antiretroviral therapy (ART) is used by around 1.3 million people, helping to progress toward the UNAIDS 95-95-95 targets for AIDS elimination by 2030. There are notable differences, as young women are three times more likely to develop HIV than young men, with greater prevalence rates in urban places like as Lusaka. Although Zambia has established several preventive measures, including pre-exposure prophylaxis (PrEP), stigma, gender-based violence, and regulatory impediments impede successful treatment and prevention initiatives [11].

HIV infection among Zambian youth is mostly linked to individual socioeconomic characteristics rather than community influences, with education being a key predictor of lower HIV infection probabilities. Individual-level prevention efforts should therefore be prioritized in Zambia's HIV response [5]. Geographic differences in HIV prevalence in Zambia suggest that metropolitan areas have greater rates than rural areas, with provinces such as Lusaka and Copperbelt being especially affected. This geographical understanding is critical for designing targeted interventions and allocating resources. Gender inequality, early sexual debut, restricted economic possibilities, and gender-based violence all contribute to the disproportionate impact of the HIV epidemic on Zambian young women. According to recent research, young women in Sub-Saharan Africa are more likely than young men to develop HIV. To reduce HIV incidence, it is critical to address the social and structural variables that contribute to gender differences in HIV risk [10].

Despite substantial HIV research in Sub-Saharan Africa, recent nationally representative data for Zambia are lacking. Previous research relied heavily on previous Demographic and Health Surveys, which may not accurately reflect the present dynamics of the HIV pandemic [12–17]. The limited availability of studies using the most recent Zambia Demographic and Health Survey (ZDHS 2024) has created a substantial knowledge gap regarding HIV prevalence and associated factors among women. This study intends to close this gap by leveraging ZDHS 2024 data and employing multilevel modeling to provide up-to-date findings relevant to HIV prevention policies and interventions. The study uses recent ZDHS 2024 data to investigate the prevalence and determinants of HIV infection among Zambian women. It investigates sociodemographic, behavioral, and health-related factors that influence HIV status among women aged 15 to 49.

## Methodology

### Data Source and Study Design

This study used a cross-sectional analytical design with secondary data from the Zambia Demographic and Health Survey 2024. Cross-sectional studies are commonly used in epidemiological research to quantify illness prevalence and identify related risk factors in a population at a given time. Zambia is administratively divided into numerous provinces, with a varied population distribution between urban and rural areas. Young people make up a sizable section of the population, with those aged 15 to 24 accounting for a sizable proportion [18]. The 2024 Zambia Demographic and Health Survey used a sampling frame drawn from the 2022 Census of Population and Housing, which included ten provinces, 116 districts, and 36,770 enumeration areas. The selection process was two-staged: first, 545 EAs were randomly chosen based on size and stratified by urban and rural areas. Following that, 25 households were randomly chosen from each designated EA, resulting in a sample of 13,625 households, nearly all of which were inhabited. Interviews with 13,951 women and 12,585 men from these families yielded response rates of 97% and 94%, respectively. The findings are based on demographics at the national, urban, rural, and provincial levels [18].

### Outcome Variable

The study focused on women aged 15 to 49 who took part in the ZDHS 2024 and had reliable HIV test results, omitting those with unclear HIV status or insufficient data on critical explanatory variables. The primary outcome variable of the study was HIV serostatus, which was confirmed by laboratory tests during the Zambia Demographic and Health Survey. It was converted to a binary format, with positive tests represented as "1" and negative tests as "0". This binary variable enabled logistic regression studies to quantify the chance of HIV infection among women aged 15 to 49, thereby improving measurement validity and reliability.

### Explanatory variables

The explanatory variables included a wide range of socio-demographic, behavioral, health-related, and contextual characteristics chosen based on previous research and data availability. Age, place of residence (urban/rural), region, education level, wealth index, and marital status were among the sociodemographic characteristics examined. Age at first sexual intercourse, number of lifetime sexual partners, and use of contraception were among the behavioral characteristics examined. The health-related variables were history of sexually transmitted infections (STIs), body mass index (BMI), and HPV vaccination status. In addition, partner-related factors such as education level and occupation were included to account for relationship implications on HIV risk. Variables related to knowledge and exposure, such as media exposure and understanding of pre-exposure prophylaxis (PrEP), were also evaluated. Table 1 present the list of explanatory variables used in the study.

Table 1  
List of explanatory variables used in the present study.

| Variable            | Description               | Categories                                                                 |
|---------------------|---------------------------|----------------------------------------------------------------------------|
| <b>hiv_outcome</b>  | HIV status (Outcome)      | 0 = Negative; 1 = Positive                                                 |
| <b>v025</b>         | Place of residence        | Urban; Rural                                                               |
| <b>v106</b>         | Education level           | No education; Primary; Secondary; Higher                                   |
| <b>v151</b>         | Sex of household head     | Male; Female                                                               |
| <b>v190</b>         | Wealth index              | Poorest; Poorer; Middle; Richer; Richest                                   |
| <b>v501</b>         | Marital status            | Never in union; Married; Living with partner; Widowed; Divorced; Separated |
| <b>v714</b>         | Currently working         | No; Yes                                                                    |
| <b>s1011a</b>       | Ever taken PrEP           | No; Yes                                                                    |
| <b>agefs_cat</b>    | Age at first sex          | Never had sex; ≤14; 15–17; 18–24; 25+                                      |
| <b>partners_cat</b> | Lifetime sexual partners  | 1 partner; 2–3; 4–5; 6+                                                    |
| <b>contra_cat</b>   | Contraceptive use         | Not using; Modern method; Traditional method                               |
| <b>sti12</b>        | STI in last 12 months     | No; Yes                                                                    |
| <b>forced_sex</b>   | Ever forced sex           | No; Yes                                                                    |
| <b>partner_edu</b>  | Partner's education       | No education; Primary; Secondary; Higher                                   |
| <b>hpv_vacc</b>     | HPV vaccination           | No; Yes                                                                    |
| <b>prep_know</b>    | PrEP knowledge & attitude | Poor; Good                                                                 |
| <b>occ_resp</b>     | Respondent occupation     | Not working; Professional/Skilled; Agriculture/Manual                      |
| <b>partner_occ3</b> | Partner occupation        | Not working; Professional/Skilled; Agriculture/Manual                      |
| <b>married2</b>     | Marital status (binary)   | Unmarried; Married                                                         |
| <b>bmi_cat</b>      | BMI category              | Underweight; Normal; Overweight; Obese                                     |
| <b>media_exp</b>    | Media exposure            | No; Yes                                                                    |
| <b>visit_cat</b>    | Health service visits     | One visit; Five visits                                                     |
| <b>v024</b>         | Region                    | 10 regions (Copperbelt, Eastern, Luapula, etc.)                            |

## Statistical Analysis

All statistical analyses were performed using STATA 17.0. Initially, descriptive statistics were used to estimate the prevalence of HIV among women in Zambia, presented as weighted percentages with corresponding confidence intervals to ensure national representativeness. Bivariate analyses were conducted to explore the distribution of HIV status across selected explanatory variables, including socio-demographic, economic, and behavioral characteristics. The Chi-square test of independence was employed to assess the association between HIV status and each covariate. To identify independent predictors of HIV infection, a multilevel binary logistic regression model was fitted, accounting for the hierarchical structure of the data. All graphical presentations were generated using R.

## Multilevel Mixed Effect Modeling

To identify factors associated with HIV among women in Zambia, a two-level mixed-effects logistic regression model was employed to account for the hierarchical structure of the data, with individuals nested within primary sampling units (clusters). The survey design was specified using sampling weights, strata, and cluster identifiers to ensure nationally representative estimates. A series of four models were fitted. The empty model (Model 0) contained no explanatory variables and was used to assess the extent of cluster-level variation in HIV prevalence. Model 1 included individual-level characteristics such as education, employment status, sexual behavior, reproductive health factors, and healthcare utilization. Model 2 incorporated household level variables, including place of residence, household wealth, and regional factors. Model 3 (full model) combined both individual- and contextual-level variables to estimate adjusted effects. Adjusted odds ratios (AORs) with 95% confidence intervals were reported to quantify associations. Random effects were examined to capture between-cluster variability, and the intra-class correlation coefficient (ICC) was calculated to assess the proportion of total variance attributable to clustering. Model comparison and goodness-of-fit were evaluated using log-likelihood, Akaike Information Criterion (AIC), and Bayesian Information Criterion (BIC).

## Results

### Prevalence of HIV among Reproductive Age Women in Zambia

The distribution of HIV status among women in Zambia is presented in Fig. 1. The results indicate that the majority of women were HIV-negative, accounting for 90.67% of the study population, while 9.33% were HIV-positive.

### Bivariate Analysis of Factors Associated with HIV Among Reproductive Age Women in Zambia

Table 2. summarizes the weighted bivariate associations between HIV status and selected characteristics among women in Zambia. HIV prevalence was significantly higher among urban women

(11.84%) than rural women (6.69%), and among those in female-headed households (13.04%) compared to male-headed households (7.49%) ( $p < 0.001$ ). A clear socioeconomic gradient was observed, with prevalence increasing from 5.79% in the poorest group to over 10% among wealthier groups ( $p < 0.001$ ). Marital status was strongly associated with HIV ( $p < 0.001$ ), with the highest prevalence among widowed (25.85%) and divorced (20.01%) women, and the lowest among never-married women (4.43%). Working women had higher prevalence (10.48%) than non-working women (8.11%) ( $p < 0.001$ ), while higher education was associated with lower prevalence (6.61%) ( $p = 0.045$ ). Behavioral factors showed strong associations. HIV prevalence increased markedly with the number of sexual partners, reaching 30.34% among women with six or more partners ( $p < 0.001$ ). Women reporting recent STIs also had higher prevalence (12.80% vs. 9.20%;  $p = 0.016$ ). Occupational differences were significant, with higher prevalence among women in professional roles (11.95%) ( $p < 0.001$ ). Healthcare utilization appeared protective, as women with more visits had lower prevalence (7.25%) compared to those with fewer visits (9.79%) ( $p < 0.001$ ). Significant regional variation was observed ( $p < 0.001$ ), with the highest prevalence in Western (14.38%) and Lusaka (12.68%) and the lowest in Northern (3.64%) and Muchinga (4.97%). Partner-related factors, including partner's education ( $p = 0.008$ ) and occupation ( $p = 0.043$ ), were also significant. In contrast, contraceptive use, BMI, media exposure, PrEP use, HPV vaccination, and experience of forced sexual acts showed no significant association ( $p > 0.05$ ). However, PrEP knowledge was strongly associated with HIV, with higher prevalence among women with good knowledge (13.96%) than those with poor knowledge (6.48%) ( $p < 0.001$ ).

Table 2  
Bivariate Analysis of Factors Associated with HIV Among Women in Zambia

| <b>Variables</b>             | <b>HIV Negative n (%)</b> | <b>HIV Positive n (%)</b> | <b>p-value</b> |
|------------------------------|---------------------------|---------------------------|----------------|
| <b>Place of Residence</b>    |                           |                           | < 0.001        |
| Urban                        | 5212.26 (88.16)           | 699.96 (11.84)            |                |
| Rural                        | 5251.86 (93.31)           | 376.52 (6.69)             |                |
| <b>Sex of Household Head</b> |                           |                           | < 0.001        |
| Male                         | 7145.51 (92.51)           | 578.72 (7.49)             |                |
| Female                       | 3318.62 (86.96)           | 497.76 (13.04)            |                |
| <b>Wealth Index</b>          |                           |                           | < 0.001        |
| Poorest                      | 1869.52 (94.21)           | 114.89 (5.79)             |                |
| Poorer                       | 1829.81 (92.30)           | 152.71 (7.70)             |                |
| Middle                       | 2007.72 (90.54)           | 209.74 (9.46)             |                |
| Richer                       | 2311.64 (88.01)           | 314.99 (11.99)            |                |
| Richest                      | 2445.43 (89.59)           | 284.15 (10.41)            |                |
| <b>Marital Status</b>        |                           |                           | < 0.001        |
| Never married                | 2731.37 (95.57)           | 126.62 (4.43)             |                |
| Married                      | 6298.64 (91.35)           | 596.39 (8.65)             |                |
| Living with partner          | 75.00 (85.67)             | 12.54 (14.33)             |                |
| Widowed                      | 246.40 (74.15)            | 85.91 (25.85)             |                |
| Divorced                     | 761.68 (79.99)            | 190.52 (20.01)            |                |
| Separated                    | 351.04 (84.48)            | 64.50 (15.52)             |                |
| <b>Currently Working</b>     |                           |                           | < 0.001        |
| No                           | 5159.04 (91.89)           | 455.09 (8.11)             |                |
| Yes                          | 5305.08 (89.52)           | 621.39 (10.48)            |                |
| <b>Education Level</b>       |                           |                           | 0.045          |
| No education                 | 674.42 (90.53)            | 70.55 (9.47)              |                |
| Primary                      | 4002.93 (90.16)           | 436.72 (9.84)             |                |
| Secondary                    | 4823.32 (90.59)           | 500.97 (9.41)             |                |
| Higher                       | 963.46 (93.39)            | 68.24 (6.61)              |                |

| <b>Variables</b>                 | <b>HIV Negative n (%)</b> | <b>HIV Positive n (%)</b> | <b>p-value</b> |
|----------------------------------|---------------------------|---------------------------|----------------|
| <b>Age at First Sex</b>          |                           |                           | < 0.001        |
| Never had sex                    | 534.94 (98.05)            | 10.66 (1.95)              |                |
| ≤ 14 years                       | 1817.65 (90.26)           | 196.07 (9.74)             |                |
| 15–17 years                      | 5109.55 (90.08)           | 562.47 (9.92)             |                |
| 18–24 years                      | 2855.70 (90.67)           | 293.97 (9.33)             |                |
| ≥ 25 years                       | 146.28 (91.66)            | 13.31 (8.34)              |                |
| <b>Number of Sexual Partners</b> |                           |                           | < 0.001        |
| 1 partner                        | 3477.57 (95.71)           | 156.02 (4.29)             |                |
| 2–3 partners                     | 4997.93 (90.03)           | 553.53 (9.97)             |                |
| 4–5 partners                     | 1140.73 (83.40)           | 227.12 (16.60)            |                |
| 6 + partners                     | 291.28 (69.66)            | 126.84 (30.34)            |                |
| <b>Contraceptive Method</b>      |                           |                           | 0.112          |
| Not using                        | 5626.63 (90.36)           | 600.56 (9.64)             |                |
| Modern                           | 4585.14 (90.86)           | 460.99 (9.14)             |                |
| Traditional                      | 252.35 (94.41)            | 14.93 (5.59)              |                |
| <b>STI (last 12 months)</b>      |                           |                           | 0.016          |
| No                               | 10076.49 (90.80)          | 1020.59 (9.20)            |                |
| Yes                              | 380.61 (87.20)            | 55.89 (12.80)             |                |
| <b>Respondent Occupation</b>     |                           |                           | < 0.001        |
| Not working                      | 4397.59 (92.48)           | 357.84 (7.52)             |                |
| Professional                     | 3229.16 (88.05)           | 438.34 (11.95)            |                |
| Agricultural                     | 2828.65 (91.04)           | 278.46 (8.96)             |                |
| <b>BMI Category</b>              |                           |                           | 0.105          |
| Underweight                      | 416.20 (90.84)            | 41.99 (9.16)              |                |
| Normal                           | 3212.42 (91.72)           | 289.88 (8.28)             |                |
| Overweight                       | 1064.49 (90.28)           | 114.64 (9.72)             |                |
| Obese                            | 5771.02 (90.16)           | 629.96 (9.84)             |                |
| <b>Media Exposure</b>            |                           |                           | 0.420          |

| <b>Variables</b>                        | <b>HIV Negative n (%)</b> | <b>HIV Positive n (%)</b> | <b>p-value</b> |
|-----------------------------------------|---------------------------|---------------------------|----------------|
| No                                      | 4666.46 (90.95)           | 464.57 (9.05)             |                |
| Yes                                     | 5797.66 (90.45)           | 611.91 (9.55)             |                |
| <b>Health Facility Visits</b>           |                           |                           | < 0.001        |
| One visit                               | 8517.66 (90.21)           | 924.43 (9.79)             |                |
| Five visits                             | 1946.46 (92.75)           | 152.05 (7.25)             |                |
| <b>Region</b>                           |                           |                           |                |
| Central                                 | 1190.17 (89.55)           | 138.91 (10.45)            | < 0.001        |
| Copperbelt                              | 1502.40 (90.28)           | 161.83 (9.72)             |                |
| Eastern                                 | 1214.86 (92.66)           | 96.27 (7.34)              |                |
| Luapula                                 | 767.00 (93.10)            | 56.87 (6.90)              |                |
| Lusaka                                  | 1936.86 (87.32)           | 281.30 (12.68)            |                |
| Muchinga                                | 475.18 (95.03)            | 24.86 (4.97)              |                |
| Northern                                | 754.94 (96.36)            | 28.51 (3.64)              |                |
| North-Western                           | 700.24 (94.84)            | 38.13 (5.16)              |                |
| Southern                                | 1291.93 (89.98)           | 143.86 (10.02)            |                |
| Western                                 | 630.54 (85.62)            | 105.94 (14.38)            |                |
| <b>PrEP Use</b>                         |                           |                           |                |
| No                                      | 4588.80 (87.26)           | 670.13 (12.74)            | 0.461          |
| Yes                                     | 509.85 (88.36)            | 67.13 (11.64)             |                |
| <b>Experience of Forced Sexual Acts</b> |                           |                           |                |
| No                                      | 7309.64 (90.42)           | 774.02 (9.58)             | 0.73           |
| Yes                                     | 122.90 (89.41)            | 14.55 (10.59)             |                |
| <b>Partner's Education Level</b>        |                           |                           |                |
| No education                            | 268.63 (88.44)            | 35.12 (11.56)             | 0.008          |
| Primary                                 | 2082.09 (93.26)           | 150.54 (6.74)             |                |
| Secondary                               | 3082.70 (90.74)           | 314.50 (9.26)             |                |
| Higher                                  | 780.50 (90.52)            | 81.72 (9.48)              |                |
| <b>HPV Vaccination</b>                  |                           |                           |                |

| Variables                          | HIV Negative n (%) | HIV Positive n (%) | p-value |
|------------------------------------|--------------------|--------------------|---------|
| No                                 | 732.84 (98.17)     | 13.63 (1.83)       | 0.435   |
| Yes                                | 1297.86 (98.69)    | 17.20 (1.31)       |         |
| <b>Partner's Occupation</b>        |                    |                    |         |
| Not working                        | 814.77 (91.17)     | 78.94 (8.83)       | 0.043   |
| Professional                       | 1615.97 (89.68)    | 186.05 (10.32)     |         |
| Agricultural                       | 3909.90 (92.00)    | 339.95 (8.00)      |         |
| <b>Marital Status</b>              |                    |                    |         |
| Unmarried                          | 4090.48 (89.74)    | 467.55 (10.26)     | 0.015   |
| Married                            | 6373.64 (91.28)    | 608.93 (8.72)      |         |
| <b>PrEP Knowledge and Attitude</b> |                    |                    |         |
| Poor PrEP knowledge                | 6681.36 (93.52)    | 462.84 (6.48)      | < 0.001 |
| Good PrEP knowledge                | 3782.76 (86.04)    | 613.64 (13.96)     |         |

## Distribution of HIV Status by Wealth Index among Reproductive Age Women

Figure 2 illustrates the distribution of HIV status across different wealth index categories. The prevalence of HIV-positive individuals increased progressively from the poorest to the richer households. Specifically, the proportion of HIV-positive individuals was lowest among the poorest group (5.79%) and poorer group (7.70%), while higher proportions were observed among the middle (9.46%), richer (11.99%), and richest (10.41%) groups. Conversely, the percentage of HIV-negative individuals declined across increasing wealth categories, ranging from 94.21% among the poorest households to 88.01% among the richer households. Overall, the findings suggest a relatively higher prevalence of HIV positivity among individuals belonging to higher wealth index groups.

## Distribution of HIV Status by Place of Residence among Reproductive Age Women

Figure 3 shows the distribution of HIV status by place of residence. The prevalence of HIV-positive individuals was considerably higher among urban residents (11.84%) compared with rural residents (6.69%). Conversely, HIV-negative status was more prevalent in rural areas (93.31%) than in urban areas (88.16%). These findings indicate that HIV infection was relatively more common among individuals living in urban settings than among those residing in rural areas.

# Determinants of HIV among Reproductive Age Women in Zambia

Table 3 presents the results of the multilevel mixed-effects logistic regression analysis (Model III) examining factors associated with HIV infection among women in Zambia. Place of residence was significantly associated with HIV status. Women residing in rural areas had lower odds of HIV infection compared to their urban counterparts (AOR = 0.60; 95% CI: 0.43–0.82). Education showed a protective effect, as women with higher education had substantially reduced odds of HIV (AOR = 0.33; 95% CI: 0.18–0.58), while those with secondary education also exhibited lower risk (AOR = 0.63; 95% CI: 0.42–0.94) compared to women with no education. Sexual behavior was strongly associated with HIV risk. Women reporting multiple sexual partners had significantly higher odds of HIV, with the likelihood increasing sharply with the number of partners: 2–3 partners (AOR = 2.37; 95% CI: 1.88–3.01), 4–5 partners (AOR = 3.64; 95% CI: 2.66–4.97), and 6 or more partners (AOR = 7.40; 95% CI: 4.80–11.41). Additionally, women who reported having a sexually transmitted infection (STI) in the past 12 months were more likely to be HIV-positive (AOR = 1.53; 95% CI: 1.03–2.27). Contraceptive use was also associated with HIV status, with women using traditional methods showing lower odds of HIV infection (AOR = 0.47; 95% CI: 0.24–0.92) compared to non-users, while modern contraceptive use was not significantly associated. Furthermore, frequent health facility visits appeared protective, as women with five visits had lower odds of HIV (AOR = 0.65; 95% CI: 0.49–0.86) compared to those with only one visit. Household economic status demonstrated a positive association with HIV prevalence. Compared to women from the poorest households, those in the poorer (AOR = 1.60; 95% CI: 1.10–2.33), middle (AOR = 1.85; 95% CI: 1.25–2.74), richer (AOR = 2.07; 95% CI: 1.32–3.27), and richest (AOR = 2.35; 95% CI: 1.41–3.92) wealth quintiles had progressively higher odds of HIV infection. Regional variation was also evident. Women from Muchinga (AOR = 0.37; 95% CI: 0.18–0.75), Northern (AOR = 0.44; 95% CI: 0.25–0.79), and North-Western provinces (AOR = 0.28; 95% CI: 0.15–0.53) had significantly lower odds of HIV compared to the reference region, whereas women from Western province had higher odds (AOR = 1.60; 95% CI: 1.00–2.56).

Table 3

Determinants of HIV among Reproductive Age Women in Zambia using Multilevel Mixed-Effects Logistic Regression

| Variables                        | Model 0 | Model I AOR<br>(95% CI) | Model II AOR<br>(95% CI) | Model III AOR<br>(95% CI) |
|----------------------------------|---------|-------------------------|--------------------------|---------------------------|
| <b>Fixed Effects Model</b>       |         |                         |                          |                           |
| <b>Place of residence</b>        |         |                         |                          |                           |
| Urban                            |         |                         | 1                        | 1                         |
| Rural                            |         |                         | 0.53*** (0.42–0.68)      | 0.60** (0.43–0.82)        |
| <b>Education level</b>           |         |                         |                          |                           |
| No education                     |         | 1                       |                          | 1                         |
| Primary                          |         | 0.79 (0.55–1.15)        |                          | 0.73 (0.50–1.07)          |
| Secondary                        |         | 0.84 (0.57–1.23)        |                          | 0.63* (0.42–0.94)         |
| Higher                           |         | 0.46** (0.26–0.81)      |                          | 0.33*** (0.18–0.58)       |
| <b>Currently working</b>         |         |                         |                          |                           |
| No                               |         | 1                       |                          | 1                         |
| Yes                              |         | 1.00 (0.71–1.41)        |                          | 0.96 (0.68–1.35)          |
| <b>Sex of household head</b>     |         |                         |                          |                           |
| Male                             |         |                         | 1                        | 1                         |
| Female                           |         |                         | 1.62*** (1.41–1.85)      | 1.16 (0.91–1.46)          |
| <b>Number of sexual partners</b> |         |                         |                          |                           |
| 1 partner                        |         | 1                       |                          | 1                         |
| 2–3 partners                     |         | 2.39*** (1.89–3.02)     |                          | 2.37*** (1.88–3.01)       |
| 4–5 partners                     |         | 3.83*** (2.82–5.21)     |                          | 3.64*** (2.66–4.97)       |
| 6 + partners                     |         | 7.75*** (5.05–11.91)    |                          | 7.40*** (4.80–11.41)      |

| Variables                    | Model 0 | Model I AOR<br>(95% CI) | Model II AOR<br>(95% CI) | Model III AOR<br>(95% CI) |
|------------------------------|---------|-------------------------|--------------------------|---------------------------|
| <b>Fixed Effects Model</b>   |         |                         |                          |                           |
| <b>Place of residence</b>    |         |                         |                          |                           |
| <b>Contraceptive method</b>  |         |                         |                          |                           |
| Not using                    |         | 1                       |                          | 1                         |
| Modern                       |         | 0.89 (0.74–1.07)        |                          | 0.88 (0.73–1.06)          |
| Traditional                  |         | 0.47* (0.24–0.91)       |                          | 0.47* (0.24–0.92)         |
| <b>STI (last 12 months)</b>  |         |                         |                          |                           |
| No                           |         | 1                       |                          | 1                         |
| Yes                          |         | 1.46 (0.99–2.17)        |                          | 1.53* (1.03–2.27)         |
| <b>Partner's education</b>   |         |                         |                          |                           |
| No education                 |         | 1                       |                          | 1                         |
| Primary                      |         | 0.65 (0.42–1.01)        |                          | 0.65 (0.42–1.01)          |
| Secondary                    |         | 0.76 (0.49–1.17)        |                          | 0.64* (0.41–1.00)         |
| Higher                       |         | 0.79 (0.47–1.33)        |                          | 0.61 (0.36–1.05)          |
| <b>Respondent occupation</b> |         |                         |                          |                           |
| Not working                  |         | 1                       |                          | 1                         |
| Professional                 |         | 1.26 (0.86–1.82)        |                          | 1.13 (0.78–1.64)          |
| Manual                       |         | 0.97 (0.66–1.41)        |                          | 1.21 (0.82–1.78)          |
| <b>Partner occupation</b>    |         |                         |                          |                           |
| Not working                  |         | 1                       |                          | 1                         |
| Professional                 |         | 1.08 (0.78–1.51)        |                          | 0.89 (0.63–1.25)          |

| Variables                  | Model 0 | Model I AOR<br>(95% CI) | Model II AOR<br>(95% CI) | Model III AOR<br>(95% CI) |
|----------------------------|---------|-------------------------|--------------------------|---------------------------|
| <b>Fixed Effects Model</b> |         |                         |                          |                           |
| <b>Place of residence</b>  |         |                         |                          |                           |
| Manual                     |         | 0.91 (0.68–1.23)        |                          | 0.83 (0.61–1.12)          |
| <b>BMI category</b>        |         |                         |                          |                           |
| Underweight                |         | 1                       |                          | 1                         |
| Normal                     |         | 0.66 (0.39–1.10)        |                          | 0.67 (0.39–1.13)          |
| Overweight                 |         | 0.85 (0.49–1.48)        |                          | 0.75 (0.43–1.30)          |
| Obese                      |         | 0.88 (0.53–1.45)        |                          | 0.83 (0.50–1.37)          |
| <b>Health visits</b>       |         |                         |                          |                           |
| One visit                  |         | 1                       |                          | 1                         |
| Five visits                |         | 0.62*** (0.47–0.82)     |                          | 0.65** (0.49–0.86)        |
| <b>Wealth index</b>        |         |                         |                          |                           |
| Poorest                    |         |                         | 1                        | 1                         |
| Poorer                     |         |                         | 1.35* (1.03–1.76)        | 1.60* (1.10–2.33)         |
| Middle                     |         |                         | 1.25 (0.94–1.66)         | 1.85** (1.25–2.74)        |
| Richer                     |         |                         | 1.20 (0.88–1.64)         | 2.07** (1.32–3.27)        |
| Richest                    |         |                         | 1.01 (0.72–1.41)         | 2.35** (1.41–3.92)        |
| <b>Region</b>              |         |                         |                          |                           |
| Reference region           |         |                         | 1                        | 1                         |
| Muchinga                   |         |                         | 0.45** (0.28–0.73)       | 0.37** (0.18–0.75)        |
| Northern                   |         |                         | 0.33*** (0.21–0.52)      | 0.44** (0.25–0.79)        |

| Variables                   | Model 0          | Model I AOR<br>(95% CI) | Model II AOR<br>(95% CI) | Model III AOR<br>(95% CI) |
|-----------------------------|------------------|-------------------------|--------------------------|---------------------------|
| <b>Fixed Effects Model</b>  |                  |                         |                          |                           |
| <b>Place of residence</b>   |                  |                         |                          |                           |
| North Western               |                  |                         | 0.40*** (0.27–0.62)      | 0.28*** (0.15–0.53)       |
| Western                     |                  |                         | 1.42* (1.02–1.98)        | 1.60* (1.00–2.56)         |
| <b>Random Effects Model</b> |                  |                         |                          |                           |
| PSU variance                | 0.40 (0.29–0.56) | 0.40 (0.24–0.64)        | 0.18 (0.10–0.30)         | 0.22 (0.11–0.44)          |
| ICC (%)                     | 10.79%           | 10.73%                  | 5.09%                    | 6.37%                     |
| <b>Model Fitness</b>        |                  |                         |                          |                           |
| Log-likelihood              | -3531.64         | -1847.11                | -3433.85                 | -1791.30                  |
| AIC                         | 7067.29          | 3740.22                 | 6901.71                  | 3658.60                   |
| BIC                         | 7081.99          | 3897.15                 | 7026.72                  | 3917.87                   |
| Clusters (PSU)              | 545              | 545                     | 545                      | 545                       |

## Discussion

This study found that HIV prevalence among reproductive-age women in Zambia remains notable, affecting 9.33% of women. The burden of HIV is unevenly distributed, with higher prevalence observed among urban residents, wealthier households, and certain regions such as Western and Lusaka provinces. Both socio-demographic and behavioral factors play important roles. Women who were widowed or divorced, currently working, and those living in female-headed households showed higher HIV prevalence. Risk was strongly associated with sexual behavior, particularly having multiple sexual partners and a history of sexually transmitted infections. Multilevel analysis confirmed that these associations persist after adjustment. Rural residence, higher education, and frequent health facility visits were protective, while increasing wealth status, multiple sexual partners, and recent STIs significantly increased the likelihood of HIV infection. Regional disparities also remained evident.

Findings from this study indicate that approximately one in every ten women in the studied population of reproductive-age women in Zambia is living with HIV, demonstrating a persistently high burden of infection. Despite notable progress in HIV prevention and treatment programs over recent decades, HIV infection continues to be a major public health concern among women in Zambia and across sub-Saharan Africa. Previous evidence indicates that the HIV epidemic in sub-Saharan Africa persists

because of ongoing new infections, population growth, and improved survival resulting from expanded antiretroviral therapy (ART) coverage [19]. Furthermore, a recent multi-country African study reported that Southern African countries continue to experience the highest HIV burden among reproductive-age women, with Zambia remaining one of the heavily affected countries in the region [20].

The present study identified considerable geographic and socioeconomic disparities in HIV prevalence. Women residing in urban areas had significantly higher odds of HIV infection than rural women. Similar findings have been documented in previous studies showing that urban residence is strongly associated with HIV prevalence because urban populations generally experience greater mobility, social interaction, migration, and exposure to high-risk sexual networks [21]. Studies conducted in sub-Saharan Africa further demonstrated that HIV prevalence tends to cluster in urban centers and transport corridors where population movement is common [22, 23]. The higher prevalence observed in Lusaka and Western provinces in the current study may therefore reflect urbanization, labor-related mobility, and dense sexual networks that facilitate HIV transmission.

Interestingly, women from wealthier households had higher HIV prevalence compared with poorer women. This finding is consistent with earlier studies from sub-Saharan Africa that reported a positive association between household wealth and HIV infection [24–26]. One possible explanation is that wealthier individuals may have greater mobility, increased social connectivity, and higher likelihood of engaging in multiple or concurrent sexual partnerships. Previous literature also suggests that economic advancement alone may not necessarily reduce HIV transmission if risky sexual behavior persists [26]. In Zambia, district-level analyses similarly observed that HIV prevalence was positively associated with expenditure and socioeconomic status [26].

This study further demonstrated that widowed and divorced women were more likely to be HIV-positive than married women. Similar observations have been reported across sub-Saharan Africa, where women outside stable marital unions consistently exhibit higher HIV vulnerability [27]. Widowhood may reflect prior exposure to infected spouses, while divorce or separation may increase economic and social vulnerability, potentially leading to engagement in higher-risk sexual relationships. Additionally, women living in female-headed households showed higher HIV prevalence. Previous Zambian studies have also found positive associations between female-headed households and HIV prevalence [24]. This relationship may partly reflect the socioeconomic disadvantages experienced by women heading households independently, including poverty, reduced social protection, and loss of partners due to HIV-related mortality.

Behavioral factors emerged as major determinants of HIV infection in this study. Women reporting multiple sexual partners had substantially higher odds of HIV infection. This finding aligns with extensive evidence from sub-Saharan Africa demonstrating that concurrent and multiple sexual partnerships are key drivers of HIV transmission [28]. Previous studies noted that many concurrent sexual relationships among African women involve transactional or quasi-transactional dynamics influenced by poverty, gender inequality, and consumer-related socioeconomic pressures [28]. Women's vulnerability is further

intensified by unequal gender relations and limited capacity to negotiate safer sexual practices. Women often remain unable to fully utilize existing HIV prevention strategies, including condom negotiation and early treatment initiation within relationships [29]. Moreover, previous evidence indicates that women experiencing forced sexual encounters, early sexual debut, or intimate partner violence are at elevated risk of HIV infection [30–32]. These findings collectively highlight the importance of integrating gender empowerment, violence prevention, and sexual health education into HIV prevention programs.

The strong positive association between recent sexually transmitted infections (STIs) and HIV infection observed in this study is biologically plausible and supported by substantial previous evidence. Both ulcerative and non-ulcerative STIs facilitate HIV acquisition and transmission through mucosal inflammation, epithelial disruption, and increased viral shedding [33]. Women with recent STI histories may therefore represent an especially vulnerable group requiring integrated HIV-STI prevention and treatment services. Although herpes suppressive therapies have been evaluated as HIV prevention approaches, randomized controlled trials conducted in African populations, including women from Lusaka, did not demonstrate a consistent protective effect against HIV acquisition [34]. This suggests that broader behavioral and structural interventions remain essential.

Educational attainment appeared to have a protective effect against HIV infection in this study. Women with higher education had lower odds of HIV positivity compared with women with limited education. Similar findings have been reported in Zambia, Uganda, and Thailand, where HIV prevalence declined more rapidly among highly educated populations [35]. Education likely improves awareness of HIV transmission, promotes safer sexual behavior, enhances healthcare utilization, and strengthens women's decision-making autonomy. UNESCO reviews have also highlighted that increased years of schooling are associated with safer sexual behavior and reduced HIV vulnerability in countries such as Zambia and Uganda [36]. Furthermore, studies suggest that improving educational attainment may contribute more substantially to reducing HIV transmission than poverty reduction alone [37]. These findings emphasize the importance of female education as a long-term structural intervention for HIV prevention.

Frequent health facility visits were associated with lower HIV prevalence in this study, potentially reflecting improved access to HIV counseling, testing, prevention services, and timely treatment initiation. Previous research demonstrated that early initiation of ART substantially reduces HIV transmission among sexual partners [38]. In addition, biomedical prevention approaches such as oral tenofovir (TDF) and tenofovir-emtricitabine (TDF-FTC) have shown protective effects against HIV-1 infection among heterosexual men and women [39]. The effectiveness of these preventive therapies is strongly associated with treatment adherence and detectable drug levels [40]. Increased healthcare utilization may therefore facilitate access to preventive interventions and improve awareness regarding HIV risk reduction.

The findings of this study demonstrate that HIV infection among reproductive-age women in Zambia is shaped by a complex interaction of demographic, socioeconomic, behavioral, and geographic factors. Persistent regional inequalities and behavioral vulnerabilities indicate that a “one-size-fits-all” approach

may not be sufficient for HIV control. Instead, targeted interventions focusing on high-burden regions, women with multiple sexual partners, widowed or divorced women, and women with STI histories are needed. Strengthening female education, promoting gender equity, expanding STI management services, and improving equitable access to HIV prevention and treatment services may substantially contribute to reducing HIV burden among women in Zambia.

## **Strengths of the Study**

This study has several important strengths. First, it utilized nationally representative data from the most recent Zambia Demographic and Health Survey (ZDHS 2024), which enhances the generalizability of the findings among reproductive-age women in Zambia. The use of a large sample size and standardized DHS data collection procedures improves the reliability and validity of the results. Second, this study incorporated a wide range of socio-demographic, behavioral, health-related, and contextual variables, allowing for a comprehensive assessment of factors associated with HIV infection. Third, the application of multilevel mixed-effects logistic regression accounted for the hierarchical structure of the DHS data and cluster-level variation, thereby providing more robust and accurate estimates. Additionally, the inclusion of regional analysis enabled the identification of geographic disparities in HIV prevalence, which may support targeted public health interventions and resource allocation. Finally, the use of recent data provides updated evidence regarding HIV prevalence and determinants among women in Zambia, which is important for informing current HIV prevention and policy strategies.

## **Limitations of the Study**

Despite its strengths, this study has several limitations that should be acknowledged. First, the cross-sectional nature of the ZDHS data limits the ability to establish causal relationships between explanatory variables and HIV infection. Therefore, the observed associations should be interpreted cautiously. Second, several behavioral variables, including sexual history, number of sexual partners, sexually transmitted infections, and contraceptive use, were self-reported and may be subject to recall bias or social desirability bias, particularly given the sensitive nature of HIV-related information. Third, some potentially important factors associated with HIV infection, such as partner HIV status, viral load, ART adherence, stigma, cultural practices, and detailed sexual network characteristics, were not available in the DHS dataset and therefore could not be included in the analysis. Fourth, although the study used laboratory-confirmed HIV status, the timing of HIV acquisition could not be determined. Finally, while spatial and regional variations were assessed, the study did not incorporate advanced spatial autocorrelation or hotspot analyses, which may provide deeper insights into localized HIV clustering patterns.

## **Conclusion**

This study revealed that HIV remains a substantial public health burden among reproductive-age women in Zambia, with approximately one in every ten women in the studied population living with HIV. Significant disparities in HIV prevalence were observed across socioeconomic, behavioral, and

geographic factors. Women residing in urban areas, belonging to wealthier households, reporting multiple sexual partners, and having recent sexually transmitted infections were at significantly higher risk of HIV infection. In contrast, rural residence, higher educational attainment, and frequent health facility visits appeared protective against HIV infection. Marked regional differences further highlighted the uneven distribution of HIV burden across Zambia. The findings underscore the need for targeted and context-specific HIV prevention strategies focusing on high-risk and vulnerable populations, particularly women in urban settings, high-prevalence regions, and those with risky sexual behaviors. Strengthening female education, expanding integrated HIV and STI services, promoting gender empowerment, and improving equitable access to prevention, testing, and treatment services may substantially contribute to reducing HIV transmission among women in Zambia. These findings may assist policymakers and public health stakeholders in designing evidence-based interventions to accelerate progress toward HIV epidemic control in Zambia.

## **Abbreviations**

| <b>Abbreviation</b> | <b>Full Form</b>                           |
|---------------------|--------------------------------------------|
| HIV                 | Human Immunodeficiency Virus               |
| AIDS                | Acquired Immune Deficiency Syndrome        |
| ART                 | Antiretroviral Therapy                     |
| ARV                 | Antiretroviral                             |
| CDC                 | Centers for Disease Control and Prevention |
| PCP                 | Pneumocystis carinii Pneumonia             |
| RNA                 | Ribonucleic Acid                           |
| DNA                 | Deoxyribonucleic Acid                      |
| HIV-1               | Human Immunodeficiency Virus Type 1        |
| HIV-2               | Human Immunodeficiency Virus Type 2        |
| STI                 | Sexually Transmitted Infection             |
| STIs                | Sexually Transmitted Infections            |
| HSV-2               | Herpes Simplex Virus Type 2                |
| GIS                 | Geographic Information System              |
| ZDHS                | Zambia Demographic and Health Survey       |
| DHS                 | Demographic and Health Survey              |
| EA                  | Enumeration Area                           |
| PSU                 | Primary Sampling Unit                      |
| ICC                 | Intra-Class Correlation Coefficient        |
| AOR                 | Adjusted Odds Ratio                        |
| CI                  | Confidence Interval                        |
| AIC                 | Akaike Information Criterion               |
| BIC                 | Bayesian Information Criterion             |
| BMI                 | Body Mass Index                            |
| HPV                 | Human Papillomavirus                       |
| PrEP                | Pre-Exposure Prophylaxis                   |
| TDF                 | Tenofovir Disoproxil Fumarate              |
| FTC                 | Emtricitabine                              |

|         |                                            |
|---------|--------------------------------------------|
| TDF-FTC | Tenofovir-Emtricitabine Combination        |
| UNAIDS  | Joint United Nations Programme on HIV/AIDS |
| WHO     | World Health Organization                  |
| LMICs   | Low- and Middle-Income Countries           |
| OR      | Odds Ratio                                 |
| Ref     | Reference Category                         |
| SD      | Standard Deviation                         |

## Declarations

### Ethical approval and consent to participate

The Zambia Demographic and Health Survey was ethically approved by national and international review boards, including ethics committees and the DHS programme ethics board. All respondents provided informed consent prior to interviews and biomarker collection; therefore, participation was entirely voluntary. The Demographic and Health Surveys Program make the dataset publicly available, and it does not contain any personally identifiable information.

### Competing interests

The authors declare no competing interests.

## Consent for publication

Not applicable.

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## Author Contribution

MSH conceptualized the study design and methodology. TH and MRH conducted the analysis and prepared the first draft of the manuscript. MSH reviewed and validated the draft. All authors contributed equally to the study, critically reviewed the manuscript, and approved the final version for publication.

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## Availability of data and materials

The data used in this study were obtained from the Demographic and Health Surveys (DHS) Program and are publicly accessible through the DHS website (<https://dhsprogram.com/data/>). The specific dataset analyzed for this study can also be provided by the corresponding author upon reasonable request.

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## Figures

## Distribution of HIV Status

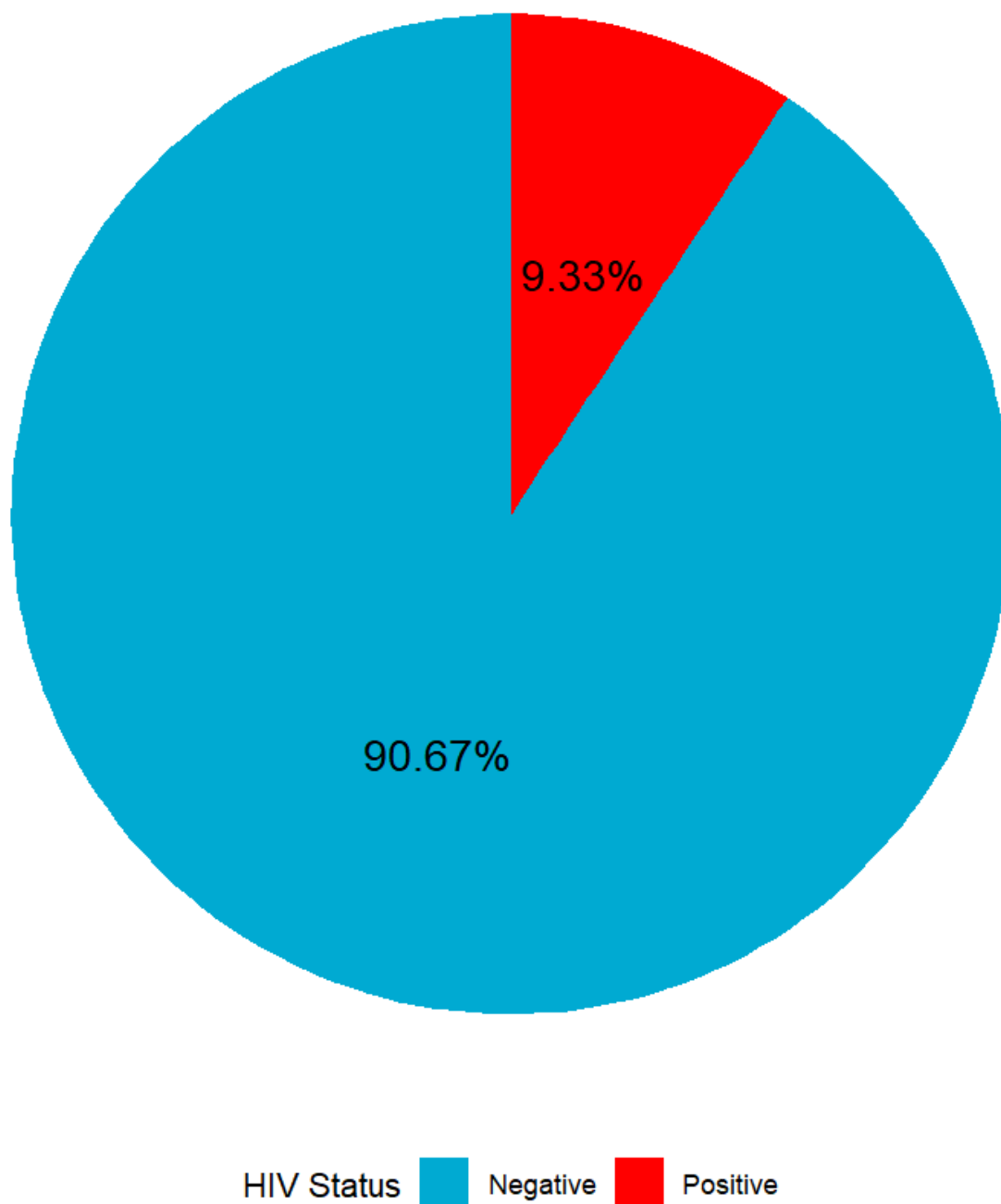


**Figure 1**

Prevalence of HIV among Reproductive Age Women in Zambia

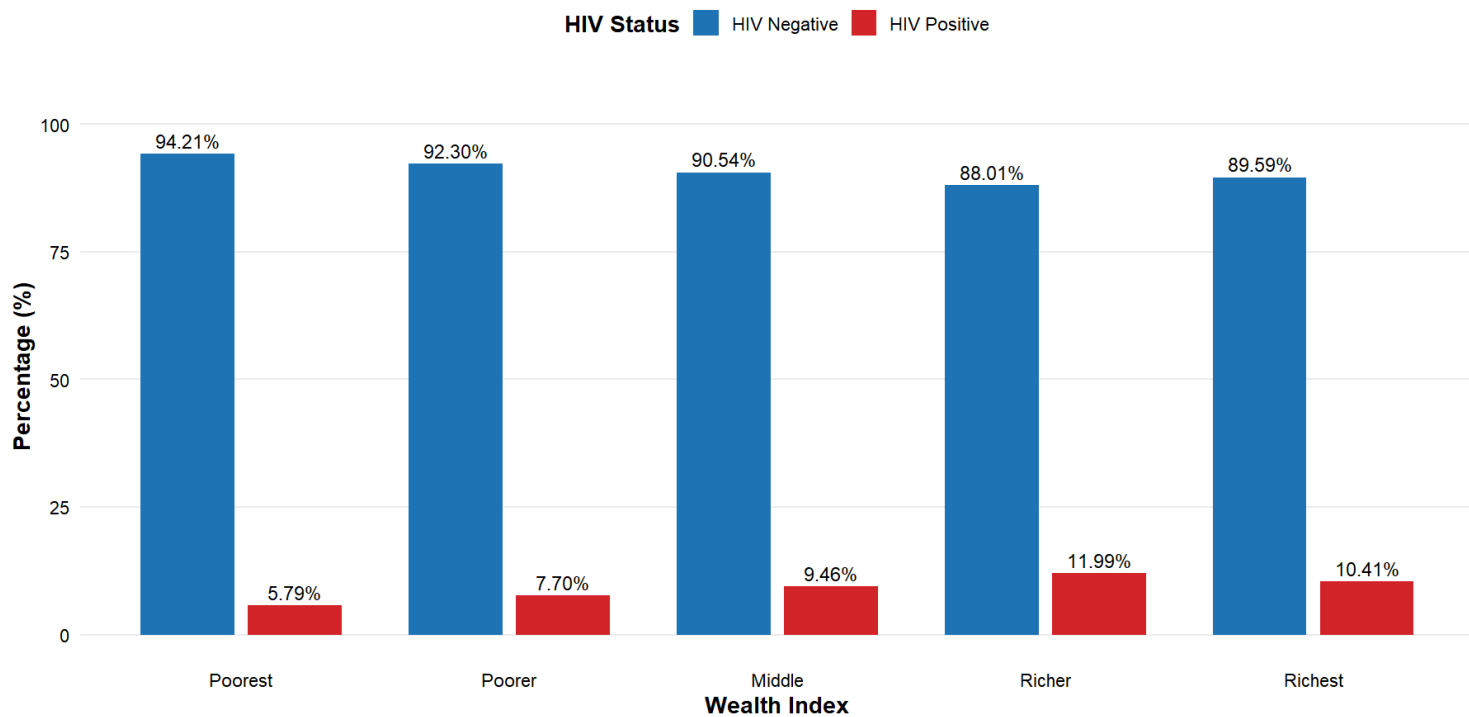


**Figure 2**

Distribution of HIV Status by Wealth Index among Reproductive Age Women

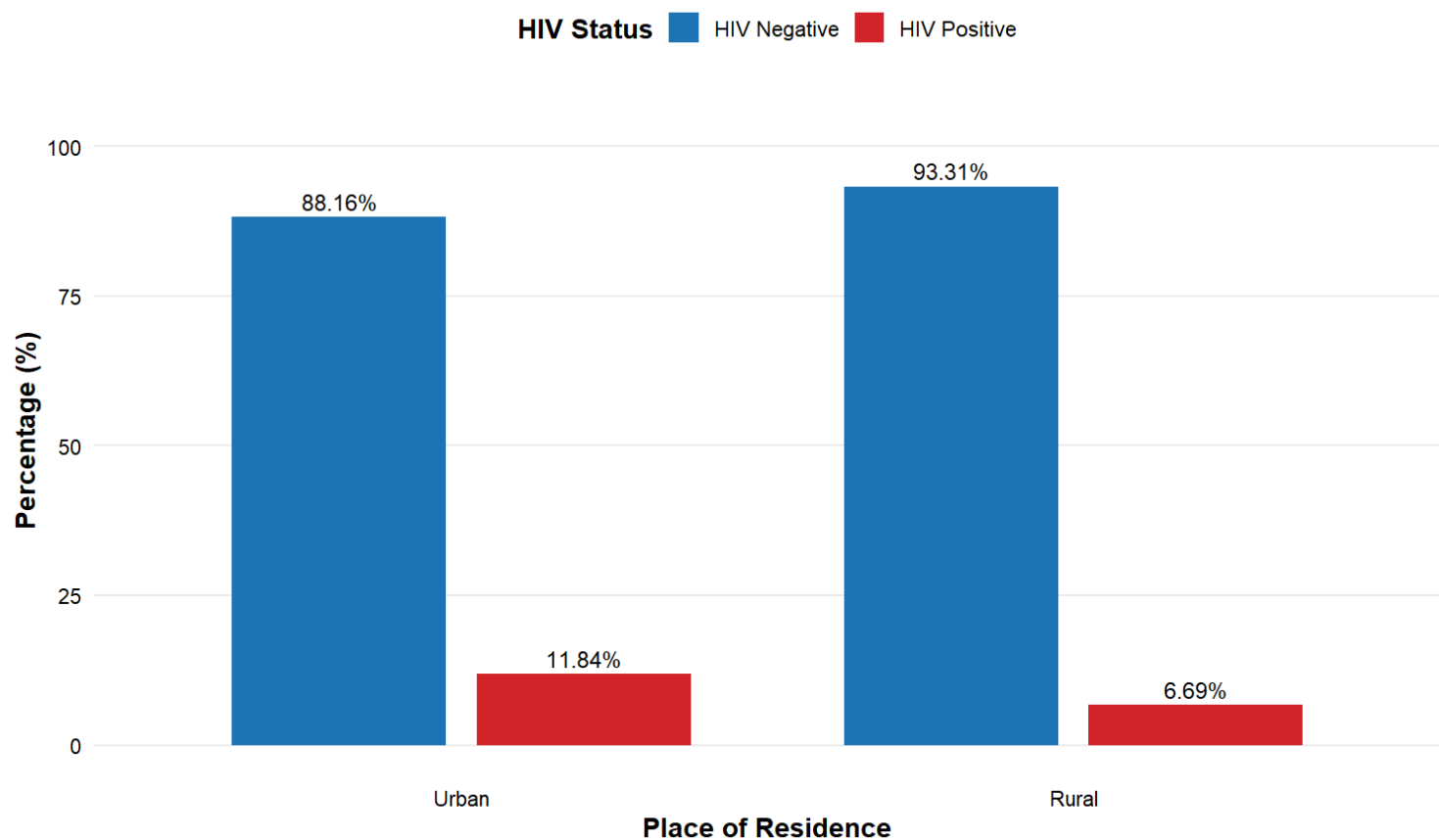


**Figure 3**

Distribution of HIV Status by Place of Residence among Reproductive Age Women