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Original article

Seroprevalence of Human Immunodeficiency Virus Infection and Demographic Correlates among Individuals Tested in Al-Jabal Al-Akhdar, Eastern Libya: A Cross-Sectional Laboratory-Based Study

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Abstract
HIV infection continues to represent a significant public health concern globally, particularly in regions with limited surveillance infrastructure. In Libya, the prevalence of HIV remains low but poorly characterized, and underreporting due to social stigma and regional disparities in testing complicates epidemiological assessments. Age is a key determinant of HIV risk, yet few studies have evaluated age-specific seroprevalence among Libyan nationals. This study aimed to assess HIV seropositivity and its demographic correlates, with a particular focus on age, gender, and location among Libyan nationals tested in Al-Bayda and Massa in Eastern Libya during 2025. A cross-sectional, laboratory-based study was conducted from January to October 2025. Blood samples from 195 Libyan nationals were analyzed using rapid diagnostic tests for HIV antibodies, following manufacturer guidelines and national testing algorithms. Demographic data, including age, gender, and location, were extracted from laboratory records. Statistical analysis was performed in R software, including descriptive statistics and Fisher's exact test for categorical variables. The association between age and HIV serostatus was examined using the Wilcoxon rank-sum test, and age distribution by serostatus was visualized with a box plot. Of the 195 participants, 120 (61.5%) were male, and 75 (38.5%) were female. The mean age was 35.8 ± 15.1 years (range: 6–89 years). One individual (0.5%) tested positive for HIV, a 34-year-old male. The Wilcoxon rank-sum test comparing age distributions between HIV-positive and HIV-negative individuals indicated no statistically significant difference (W = 61, p = 0.528). Most participants were adults aged 25–45 years, aligning with globally recognized high-risk age groups. HIV seroprevalence among Libyan nationals in Eastern Libya remains very low, with minimal age-related differences observed. However, the findings emphasize the need for continued laboratory-based surveillance, targeted testing, and demographic-focused public health strategies to monitor potential shifts in age-related HIV risk.
Keywords. *HIV, Libya, Age, Seroprevalence, Gender, Epidemiology, Cross-sectional Study.*

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Introduction

Human Immunodeficiency Virus (HIV) remains a major global health challenge, causing lifelong immunodeficiency and predisposing infected individuals to opportunistic infections and age-related comorbidities [10, 12]. According to UNAIDS, approximately 39 million people were living with HIV worldwide by the end of 2023, with marked variations in prevalence, demographic distribution, and access to treatment across regions [13]. Age is a critical factor influencing HIV exposure and disease progression, with young adults and middle-aged populations generally representing the highest-risk groups [9, 13].

HIV primarily targets CD4+ T lymphocytes, leading to progressive immune dysfunction. The virus integrates into host DNA, establishing latent reservoirs that contribute to lifelong persistence and complicate eradication efforts [12, 14]. Chronic HIV infection accelerates immunosenescence and predisposes patients to comorbidities typically associated with older age, including cardiovascular disease, metabolic disorders, and neurocognitive decline [8, 10]. Consequently, age-specific surveillance is crucial for identifying at-risk populations and designing tailored interventions [8, 10]. In Libya, HIV prevalence remains low (<1%) but exhibits regional heterogeneity. Western and southern regions have historically shown higher case clustering, while Eastern Libya, particularly Al-Bayda, lacks robust epidemiological data [3, 9]. Factors contributing to underdiagnosis include limited laboratory capacity, social stigma, and irregular reporting [2]. Existing national and regional studies indicate that males and adults aged 25–45 are more frequently tested due to occupational health requirements, pre-marital screenings, and voluntary testing programs [1, 6].

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This study was designed to provide a comprehensive assessment of HIV seropositivity among Libyan nationals in Eastern Libya, with a specific focus on age-related patterns, demographic correlates including gender and location, and the application of inferential analysis to age-HIV associations using the Wilcoxon rank-sum test

Methods

Study Design and Setting

A cross-sectional, laboratory-based study was conducted from January to October 2025 in Al-Bayda and Massa, cities in the Al-Jabal Al-Akhdar district of Eastern Libya. The participating laboratories operate under the regional health authority and adhere to national diagnostic guidelines set by the Libyan National Center for Disease Control (NCDC). Both retrospective and prospectively collected data were included.

Study Population

The study population consisted of Libyan nationals of all ages and both genders who underwent HIV testing during the study period. Non-Libyan individuals or those with incomplete demographic data were excluded. The final dataset included 195 participants.

Data Collection

Demographic data (age, gender, and location) and HIV test results were extracted from laboratory registers. Personal identifiers were removed to maintain confidentiality.

Laboratory Testing

Blood samples were collected via venipuncture into EDTA-coated tubes and transported to the regional laboratories under standard biosafety conditions. HIV antibody screening was performed using the Determine™ HIV-1/2 rapid diagnostic test (Abbott Diagnostics), which employs immunochromatographic lateral flow technology for the simultaneous detection of HIV-1 and HIV-2 antibodies. Tests were conducted at room temperature according to manufacturer instructions, with results interpreted within 15–20 minutes.

Samples yielding reactive results on the initial RDT underwent confirmatory testing using a second, independent rapid assay based on a different antigenic principle to reduce false-positive outcomes, in line with the national HIV testing algorithm recommended by the Libyan National Center for Disease Control (NCDC). Test quality was ensured through the use of positive and negative control samples at the start of each testing batch. Laboratory personnel performing the assays were trained and certified in biosafety level 2 (BSL-2) procedures, including the proper handling of potentially infectious materials, decontamination protocols, and personal protective equipment (PPE) usage. In addition to the initial screening, a subset of samples showing indeterminate results underwent repeat testing to confirm serostatus. All laboratory procedures adhered to internal quality assurance protocols, including daily calibration of pipettes, routine validation of test kits, and strict record-keeping for traceability. Data from the tests, including qualitative results (reactive/non-reactive) and batch information, were recorded in a dedicated laboratory register and cross-verified before entry into the study database.

Statistical Analysis

Data were entered and managed in R software (version 4.3.1) and analyzed using the tidyverse, janitor, ggpubr, and RColorBrewer packages. Continuous variables, including age, were summarized using mean, standard deviation (SD), median, and range to provide a comprehensive description of central tendency and dispersion. Categorical variables, including gender, location, and HIV serostatus, were expressed as frequencies and percentages.

To assess associations between HIV serostatus and demographic variables, Fisher's exact test was used for categorical comparisons due to the small number of positive cases, ensuring accurate p-values in the presence of low expected frequencies. For continuous variables, the relationship between age and HIV serostatus was analyzed using the Wilcoxon rank-sum test (with continuity correction), chosen as a non-parametric alternative to the t-test given the small number of HIV-positive participants and potential non-normality of the age distribution. Graphical methods were applied to support statistical analysis, including histograms to visualize the age distribution, boxplots to examine age differences by HIV serostatus, and grouped bar charts to depict the distribution of HIV positivity across genders and locations. Data visualization was enhanced with color palettes and clear annotations to facilitate interpretability.

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All statistical tests were two-tailed, and a significance threshold of $p < 0.05$ was used. Additionally, data quality checks, including outlier detection and verification of variable coding, were performed before analysis to ensure reliability and reproducibility.

Ethical Considerations

The study utilized de-identified routine laboratory data, with no direct participant contact. All procedures followed confidentiality and data protection standards.

Results

A total of 195 blood samples from Libyan nationals were analyzed between January and October 2025. The study population included both male and female participants, residing primarily in Al-Bayda, with only a single participant from Massa. The demographic characteristics, HIV serostatus, and age-related analyses are described in detail below.

Demographic Characteristics

Among the participants, 120 individuals (61.5%) were male, and 75 (38.5%) were female. This male predominance reflects patterns of occupational health screening and sociocultural factors that may limit female participation in voluntary testing programs. The mean age of participants was 35.84 ± 15.15 years, with a median of 33 years and a range of 6 to 89 years. Most participants were concentrated in the 25–45-year age range, representing the economically active adult population (Figure 1). The distribution of participants by location indicated that 194 (99.5%) resided in Al-Bayda, and only one participant (0.5%) was from Massa, highlighting the central role of Al-Bayda as a regional laboratory hub for HIV testing.

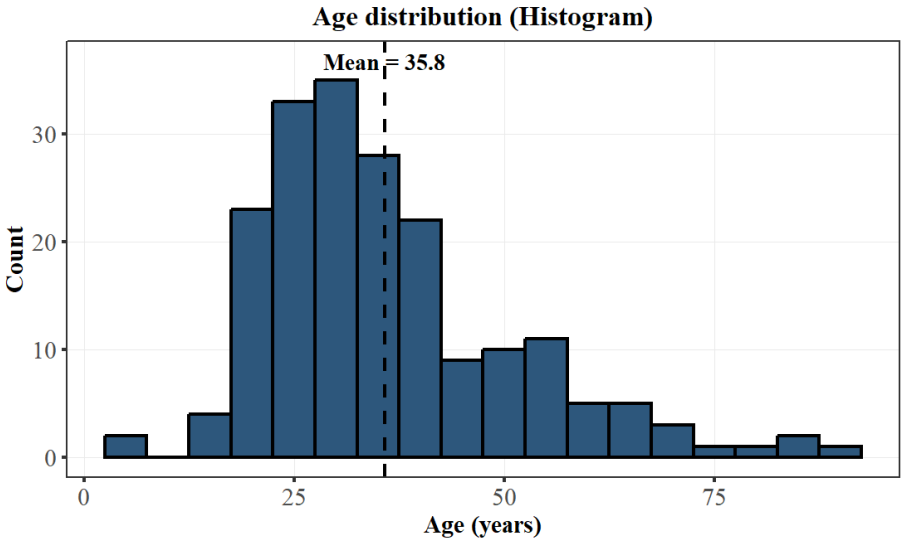

Figure 1. Age distribution of Libyan nationals tested for HIV infection (n = 195). The histogram illustrates the majority of participants aged 25–45, with a mean age of 35.84 years indicated by a red line, reflecting the most socioeconomically active population.

HIV Serostatus and Gender

Of the 195 samples tested, a single individual (0.5%) was seropositive for HIV antibodies, while the remaining 194 participants (99.5%) were seronegative. The positive case was a 34-year-old male resident of Al-Bayda. A grouped bar chart of HIV serostatus by gender (Figure 2) shows that all females tested negative, while among males, 119 (99.2%) were negative and 1 (0.8%) was positive. Fisher's exact test revealed no statistically significant association between gender and HIV status ($p = 1.0$), consistent with expectations given the low prevalence [10].

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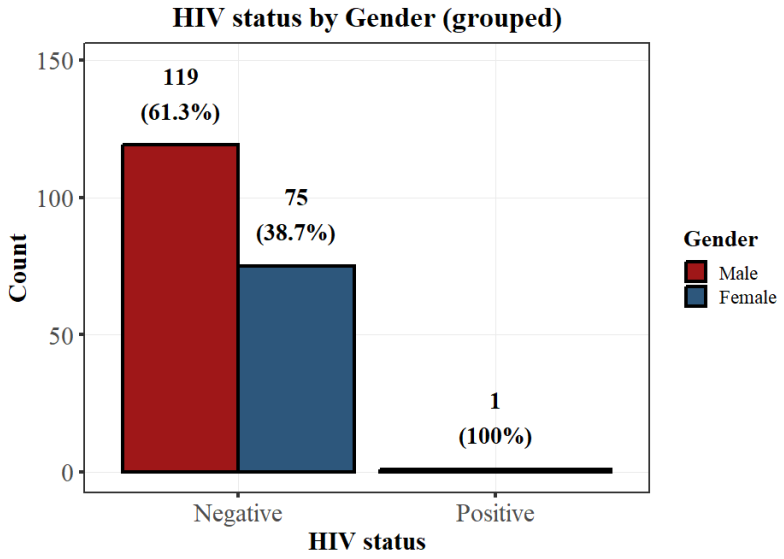

Figure 2. Gender distribution of participants. The pie chart shows 61.5% males and 38.5% females, consistent with regional screening patterns and occupational health requirements.

Age and HIV Status

To examine potential age-related differences in HIV seropositivity, the Wilcoxon rank-sum test was performed. The analysis comparing the age distributions between HIV-positive and HIV-negative participants yielded W = 61 and a p-value of 0.528, indicating no statistically significant difference in age between seropositive and seronegative individuals.

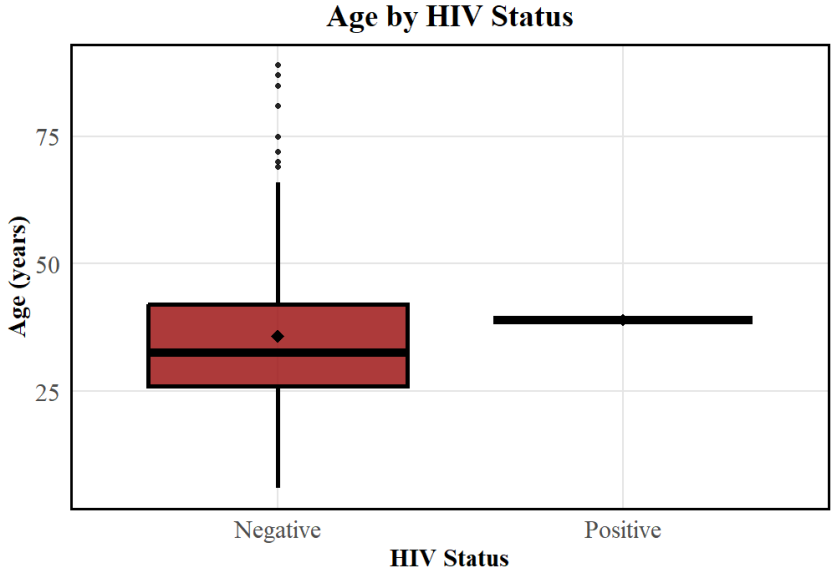

Figure 3. Box plot of age by HIV serostatus. The single HIV-positive case falls within the 25–45-year range, overlapping with the interquartile range of HIV-negative participants. Wilcoxon rank-sum test: W = 61, p = 0.528, indicating no statistically significant age difference between positive and negative participants.

This is not unexpected given the extremely small number of HIV-positive cases (n = 1), which limits statistical power but still provides descriptive insight into age patterns [12, 9]. A box plot of age by HIV serostatus (Figure 3) illustrates that the single positive case falls within the 25–45-year range, overlapping with the interquartile range of the HIV-negative participants. The plot visually emphasizes the clustering of the majority of participants within the working-age adult population while showing that the lone positive case is not an outlier in terms of age. This reinforces global trends indicating that adults in this age range remain the most epidemiologically relevant group for HIV transmission risk [13, 10].

Overall, the study confirms a very low HIV seroprevalence (0.5%) among Libyan nationals in the Al-Bayda region. The demographic data reveal a predominance of males in testing, a concentration of participants in the 25–45-year age range,

and no significant associations between HIV serostatus and either gender or age. Despite the low prevalence, these findings underscore the continued importance of targeted surveillance among adults in this region.

Discussion

This cross-sectional analysis provides an updated assessment of HIV seroprevalence among Libyan nationals in Eastern Libya. The observed prevalence of 0.5% aligns with prior national reports indicating a low endemic rate (<1%) but with regional heterogeneity [3, 9]. Our findings are consistent with studies from Tripoli and Zawia, where prevalence remains below 1% among Libyan nationals [6, 1]. Higher rates are generally observed in non-Libyan residents or occupationally exposed groups, suggesting that community-level transmission in native Libyans remains limited [11, 7]. The age analysis, including the Wilcoxon rank-sum test and box plot evaluation, shows that the single HIV-positive participant is within the 25–45-year age range, the demographic most represented in testing. This supports prior literature highlighting this age group as the highest risk for HIV acquisition globally and regionally [12, 9, 13]. The non-significant Wilcoxon result reflects the low number of positive cases rather than an absence of age-related risk.

Male predominance in the tested cohort (61.5%) corresponds with global and local patterns, where men often undergo screening for occupational or travel-related purposes more frequently than women [10, 12]. The lack of HIV-positive cases among females is consistent with regional epidemiology but does not exclude risk in underrepresented populations.

Despite low prevalence, maintaining systematic surveillance, early diagnosis, and targeted health education remains critical. The integration of laboratory-based data with regional public health strategies ensures early identification of sporadic cases and contributes to national HIV control objectives aligned with the UNAIDS 95–95–95 targets [8, 10]. The primary limitation is the small number of HIV-positive cases, which restricts statistical inference and the ability to identify age or gender trends robustly. Additionally, behavioral, clinical, and occupational data were unavailable, limiting the assessment of individual risk factors. Rapid diagnostic testing, while reliable, does not provide molecular confirmation. Nonetheless, these findings provide a foundational estimate of HIV seroprevalence in Eastern Libya, where surveillance data are limited.

Conclusion

This study demonstrates a very low HIV seroprevalence (0.5%) among Libyan nationals in the Al-Bayda region, with the single positive case occurring in a 34-year-old male. The age distribution analysis confirms that most participants, including the positive case, fall within the working-age adult range. While the epidemic remains rare among native Libyans, continued surveillance, enhanced laboratory testing, and targeted health education are essential. Strengthening regional testing infrastructure and integrating molecular confirmation will further support early detection and ongoing public health control of HIV in Libya.

Conflict of interest. Nil

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