

PREDICTIVE FACTORS FOR HIV INFECTION AMONG YOUNG PEOPLE: MODEL-BASED ANALYSIS *WEIGHT OF EVIDENCE*

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Highlights: (1) HIV prevalence among the youth population was 2.0%. (2) Young MSM and illicit drug users showed higher HIV prevalence rates. (3) Sociodemographic, behavioral, and socio-structural factors were predictive of infection.

PRE-PROOF

(as accepted)

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ABSTRACT

Introduction: The youth population is increasingly susceptible to HIV infection. Understanding the factors predicting infection can help address gaps in public health policies aimed at young people. **Objective:** To identify predictive factors for HIV infection among young people using the Weight of Evidence (WoE) model. **Method:** A cross-sectional study was conducted with 200 young people aged 15 to 24 at a Testing and Counseling Center in a large municipality in the state of Paraíba, between February and June 2021. Rapid HIV testing was performed, and the Socio-structural and Behavioral Assessment instrument (ASECOMP-HIV) was administered. The WoE model was used to identify the influence of predictive factors on the serological outcome. **Results:** The HIV test positivity rate was 2% (4 cases). Analyses revealed significant associations regarding the variables: sex ($p=0.036$), sexual orientation ($p=0.012$), living arrangements ($p=0.024$), sex in exchange for benefits ($p=0.019$), discrimination based on sexual orientation ($p=0.007$), perceived risk of HIV acquisition ($p=0.048$), non-vaginal sex ($p=0.002$), and having a relationship with an HIV-positive person ($p=0.019$). **Conclusion:** Coping with HIV infection among young people requires recognition of its complex and multifactorial nature, requiring an integrated analysis of the sociodemographic, behavioral and, above all, structural factors that condition the vulnerability of this population.

Keywords: HIV; Young Adult; Sexual Behavior; Disease Prevention; Evidence-Based Public Health; Social Factors.

INTRODUCTION

Despite significant advances in the prevention of the Human Immunodeficiency Virus (HIV), the burden of infection remains a major global health concern, given the magnitude of epidemiological indicators and the impacts on the social lives and well-being of those affected. Although the infection is preventable and effective prevention strategies exist, millions of people worldwide become infected each year, making HIV a public health challenge. Discrepancies between public policies and the population's actual needs, structural issues, systemic and financial barriers, social disparities, and human rights violations are considered significant threats to the global response to the infection¹.

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In 2022, there were 39 million people living with HIV worldwide. That same year, 1.3 million new infections were recorded.¹ Although the general trend of infection has been decreasing, the temporal evolution of the epidemic shows that populations are not uniformly vulnerable or equally affected. The prevalence of infection is significantly higher and tends to rise in key and priority populations, being more significant in younger age groups²⁻⁶.

In Brazil, 43,403 new HIV infections were reported in 2022; of these, 9,366 (21.6%) occurred among individuals aged 15 to 24. Between 2007 and June 2023, 114,593 (23.4%) cases were reported among young people aged 15 to 24, with 25% of cases occurring in males and 19.6% in females. A comparison between 2012 and 2022 shows a decrease in the AIDS detection rate among females and across all age groups. However, among males, the AIDS detection rate did not decrease in the 20–24 and 25–29 age groups.⁶

The causal relationships between the disparity in cases of HIV infection in different age groups result from the confluence of multiple factors, which include sociostructural, sociodemographic and behavioral phenomena. These elements and their complex network of interactions create a scenario in which a variety of situations are under permanent negotiation. Cultural, social, economic, religious and political variations shape individual behavior and influence the perception of risk and vulnerability of groups to HIV⁷⁻¹¹.

Particularly among young people, factors such as impaired decision-making ability, peer pressure, social norms and values, early onset of sexual activity, unprotected sex, having multiple concurrent partners, casual sexual encounters, partner violence, alcohol and illicit drug use, and sex in exchange for benefits make them more vulnerable to HIV infection.¹²⁻¹⁵. As underlying causes, structural conditions—such as violence, gender disparities, poverty, male chauvinism, sexism, racism, stigma, discrimination, and criminalization—have a greater impact in contexts of vulnerability, acting as formidable barriers to accessing citizenship, rights, and comprehensive healthcare.^{3,10,17}.

Considering the epidemiological significance, the socio-structural impacts on HIV infection and the singularities of local-regional contexts, efforts must be made with a view to improving the understanding and measurement of risk situations that increase the vulnerability of young people to HIV infection^{3,5,9,11}. Such information can influence the work dynamics established in care microspaces, support the construction of more assertive strategic prevention agendas and strengthen the response capacity of health services and the care of the Nursing team^{9,17}.

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Furthermore, it is worth highlighting that the model used in the study (WoE) has been widely used in environmental risk assessment research. In the health sector, it is still little used, characterizing its innovative potential, as it calculates the influence of categorical explanatory variables on a given outcome, predicting its occurrence¹⁶.

In this regard, the present study aimed to identify predictive factors for Acquired Immunodeficiency Virus infection among young people using the model: *Weight of Evidence*.

METHOD

This is a quantitative, cross-sectional study based on the guidelines of *Strengthening the Reporting of Observational Studies in Epidemiology* (STROBE).

The study was conducted at the Testing and Counseling Center (CTA) of a large municipality in the state of Paraíba. This service accommodates walk-in clients for STI diagnosis and serves as a referral center for the metropolitan area and surrounding municipalities.

The study population consisted of young people who sought the CTA to undergo a rapid HIV test. The sample universe was determined considering as a population basis the monthly average estimate of rapid tests carried out in 2020 at the CTA (n=500), confidence level of 95%, tolerable margin of error of 5% and an anticipated P value (prevalence) of 24%, based on the proportion of HIV cases in the age group of 15 to 24 years registered in Brazil¹⁷. Therefore, a sample of 200 participants was determined.

Participants were selected via convenience sampling (voluntary participation) based on the following inclusion criteria: being of either sex, aged 15 to 24, and unaware of their HIV serostatus. Exclusion criteria included youths outside the study's defined age range, those who declined to participate, and those unable to answer the questionnaire.

The Socio-structural and Behavioral Assessment instrument (ASECOMP-HIV)—validated in Brazil—was used; it consists of 45 questions employing various response formats (such as dichotomous, eligibility, multiple-choice, and Likert-type scales) and is divided into three domains:

a) Domain I- Sociodemographic: Age, Sex, Gender Identity, Sexual Orientation, Self-declared Race/Color, Education Level.

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b) Domain II- Socio-structural: Current occupation, Current relationship status, Parental status, Household composition (who you live with), Number of people in the household, Family income, Financial or material support, Housing situation, Mobile phone, Home internet access, Sufficiency of food in the home over the past month, History of incarceration or institutionalization, History of psychiatric treatment, Sex in exchange for benefits, Discrimination based on gender identity, Discrimination based on sexual orientation, Experience of sexual violence/abuse, First point of contact when health issues require care, Receipt of HIV prevention counseling, Difficulty obtaining condoms, Difficulty getting a rapid HIV test, Difficulty accessing the Testing and Counseling Center (CTA), Satisfaction with care received at the CTA.

c) Domain III- Behavioral: First time seeking a rapid HIV test, reason for the current test, age at first sexual intercourse, age at first consensual sexual intercourse, history of STIs, use of Post-Exposure Prophylaxis (PEP), use of Pre-Exposure Prophylaxis (PrEP), self-perceived risk of HIV acquisition, frequency of condom use, difficulty negotiating condom use, sexual practices, partner's current HIV status, history of relationships with an HIV-positive person, alcohol consumption, illicit drug use. The study's dependent variable was the HIV serological outcome (reactive or non-reactive), while the independent variables consisted of factors categorized into three domains: sociodemographic, socio-structural, and behavioral.

Data collection took place between February and June 2021 and was carried out by graduate students (at the master's and doctoral levels) who had been previously trained and qualified by the study coordinator. Participants—young people aged 15 to 24—were selected when they filled out the intake form for rapid HIV testing at the Testing and Counseling Center (CTA).

Rapid immunochromatographic tests (RTs) are widely used within public health policies to diagnose HIV infection, viral hepatitis, syphilis, and other sexually transmitted infections, and are offered free of charge at health services.¹⁸ In the present study, the tests were performed by healthcare professionals from the CTA using capillary blood samples obtained via fingerprick.

After undergoing the test, the young person was invited to participate in the study; the research objectives were explained, and—for those who agreed to take part—consent or assent forms were duly signed. Interviews took place in a private setting and lasted an average of 20 minutes, coinciding with the waiting period for the rapid test results. Upon completion

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of the interview, the young people were escorted to the post-test counseling room, where they were informed of their test results.

Participants who tested positive received support from the facility's health team, were provided with guidance and information, and had a medical appointment scheduled at the same facility. It is worth noting that there were no refusals to participate in the study or to share/include the test results. In accordance with the agreement obtained, the test results were recorded on the interview instrument by the data collectors.

Data processing and analysis

The data were ordered and typed in double entry and organized in an electronic spreadsheet using the Microsoft Excel program for Windows. The inconsistencies detected were duly corrected. Sequentially, the data were transferred to the data entry table of the Stata 17 software to carry out descriptive and inferential analyses. HIV prevalence, investigated according to rapid test positivity, was calculated considering a 95% confidence interval. To investigate the association between the independent variables (sociodemographic, sociostructural and behavioral domains) and rapid HIV test positivity, a bivariate analysis was performed using Fisher's exact test. The significance level considered was $p < 0.05$.

To analyze the significance of the independent variables on the dependent variable, based on the degree of influence of these results as possible predictor variables of the studied outcome, the binary classification model Weight of Evidence – WoE and Information Value - IV (Information Value) were used as adjustment metrics. Bivariate analysis was performed using Fisher's exact test in order to identify associations between independent variables and HIV test positivity. Additionally, the binary classification model based on WoE and IV was applied, which allow assigning numerical scores to the independent variables and estimating the strength of their association with the dependent variable. Both methods were used in a complementary way to analyze sociodemographic, sociostructural and behavioral factors associated with HIV infection in young people.

While WoE analyzes the strength of evidence of the independent variables and their categories in relation to the dependent variable¹⁹, the IV assesses the predictive weight of a set of independent (explanatory) variables in relation to the response variable, and can be used to compare the predictive power among all the independent variables.²⁰. An IV < 0.02 indicates a very weak (useless) predictor; 0.02 to < 0.1 indicates a weak relationship; 0.1 to 0.3

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indicates a relationship of medium strength; >0.3 to 0.5 indicates a strong relationship; and above 0.5 , the predictor has a very strong/suspicious relationship.²⁰ The analyses in the WoE model were performed in *software* R Studio was 4.2.3.

Ethical Aspects

All ethical guidelines governing research involving human subjects, as established in Resolution, number 466/2012 of the National Health Council, were observed. The research was approved by the Research Ethics Committee (resolution, number: 3.935.713/2020). Participants were asked to provide consent—either in writing or via fingerprint—through an Informed Consent Form (for those aged 18 and older) or an Assent Form (for those under 18).

RESULTS

Among the 200 young people studied, there was a predominance of females (112/56.0%), the 20–24 age group (122/61.0%), heterosexual orientation (129/64.5%), and self-identification as mixed-race/brown (*brown*) (115/57.5%). The majority had a secondary education (114/57.0%) and a monthly family income of 1 to 3 minimum wages (106/53.0%). The prevalence of HIV infection was 2.0% (4 individuals).

Significant associations were observed regarding the serological outcome and the following factors: sex ($p=0.036$), sexual orientation ($p=0.012$), sharing a household ($p=0.024$), sex in exchange for benefits ($p=0.019$), discrimination based on sexual orientation ($p=0.007$), perceived risk of HIV acquisition ($p=0.048$), non-vaginal sexual practices ($p=0.002$), and having a partner who was HIV-positive ($p=0.019$). It must be noted that the risk perception variable was self-reported by the participants.

Among young people living alone or with friends, the test positivity rate was 3 (8.8%); among those who had engaged in sex in exchange for benefits, it was 2 (16.7%); and among those discriminated against based on their sexual orientation, the test positivity rate was 4 (7.1%).

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Table 1: Association between significant variables identified in the sociodemographic, socio-structural, and behavioral domains and the HIV* serological outcome among young people (N[†] = 200). João Pessoa, PB, Brazil, 2021.

Variables	Rapid HIV test*		p [‡]
	Reactive (N [†] = 4) N [†] (%)	Non-reactive (N [†] =196) N [†] (%)	
Gender			0,036
Male	4 (4,6)	84 (95,4)	
Female	0	112 (100,0)	
Sexual orientation			0,012
Straight	0	129 (100,0)	
Gay	4 (8,9)	41 (91,1)	
Bisexual	0	21 (100,0)	
Pansexual	0	5 (100,0)	
The person shares a home.			0,024
Family unit	1 (0,9)	105 (99,1)	
Extended family unit	0	60 (100,0)	
Alone/friend	3 (8,8)	31 (91,2)	
Sex in exchange for benefits			0,019
Yes	2 (16,7)	10 (83,3)	
No	2 (1,1)	186 (98,9)	
Discrimination based on sexual orientation			0,007
Yes	4 (7,1)	52 (92,9)	
No	0	142 (100,0)	
I prefer not to answer	0	2 (100,0)	
Risk of having acquired HIV*			0,048
Low	1 (0,8)	125 (99,2)	
Moderate	0	28 (100,0)	
High	1 (12,5)	7 (87,5)	
I don't know	2 (5,3)	36 (94,7)	
Sexual Practice			0,002
Vaginal	0	155 (100,0)	
Non-vaginal	4 (8,9)	41 (91,1)	
The person had a sexual encounter with an HIV-positive individual. *			0,019
Yes	1 (12,5)	7 (87,5)	
No	3 (3,7)	79 (96,3)	
I don't know	0	110 (100,0)	

*HIV = Human Immunodeficiency Virus;

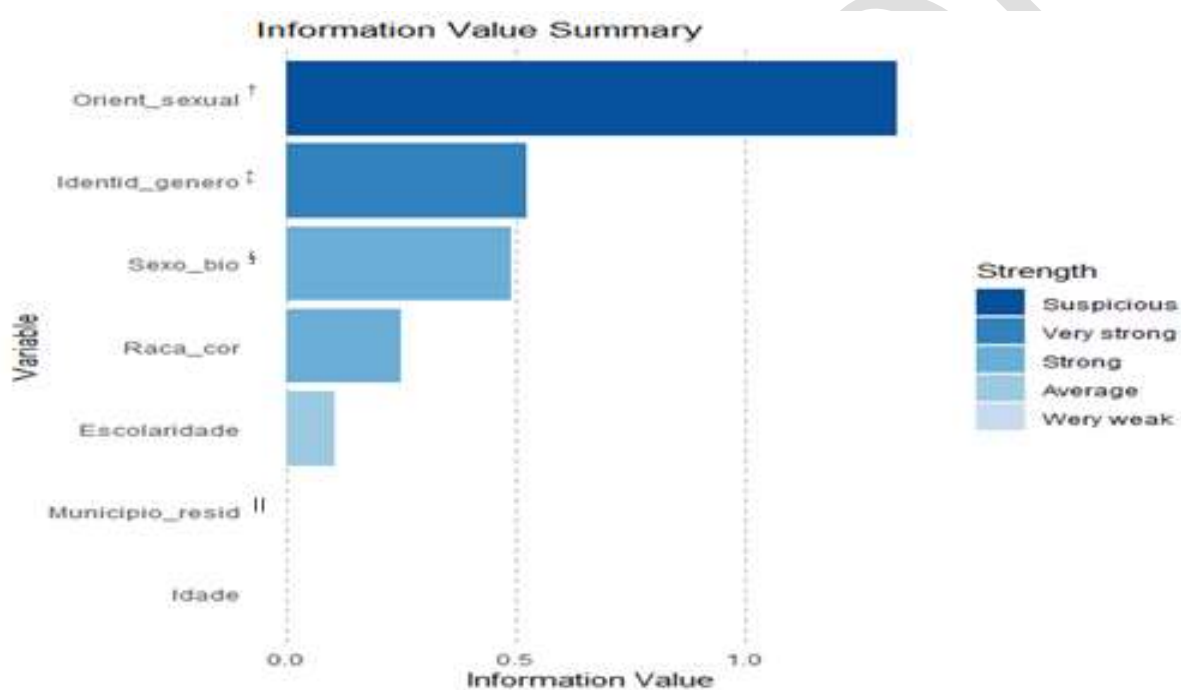
†N = Number of survey participants;

‡p = Fisher's exact test

Source: Own author.

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In the analysis of explanatory factors using the Weight of Evidence (WoE) binary classification model, it was found—within Domain I (Figure 1)—that the sexual orientation variable exhibited very strong/suspicious predictive power. The variables of gender identity, biological sex, and race/color showed informative values classified as strong to very strong. Conversely, educational attainment demonstrated lower predictive capacity. ($0,1 \leq IV < 0,3$). The variables "municipality of residence" and "age" did not yield relevant information, indicating a lack of predictive power regarding the outcome.



*WoE = Weight of Evidence;

†Orient_sexual = Sexual orientation;

‡Identid_genero = Gender identity;

§Sexo_bio = Biological sex;

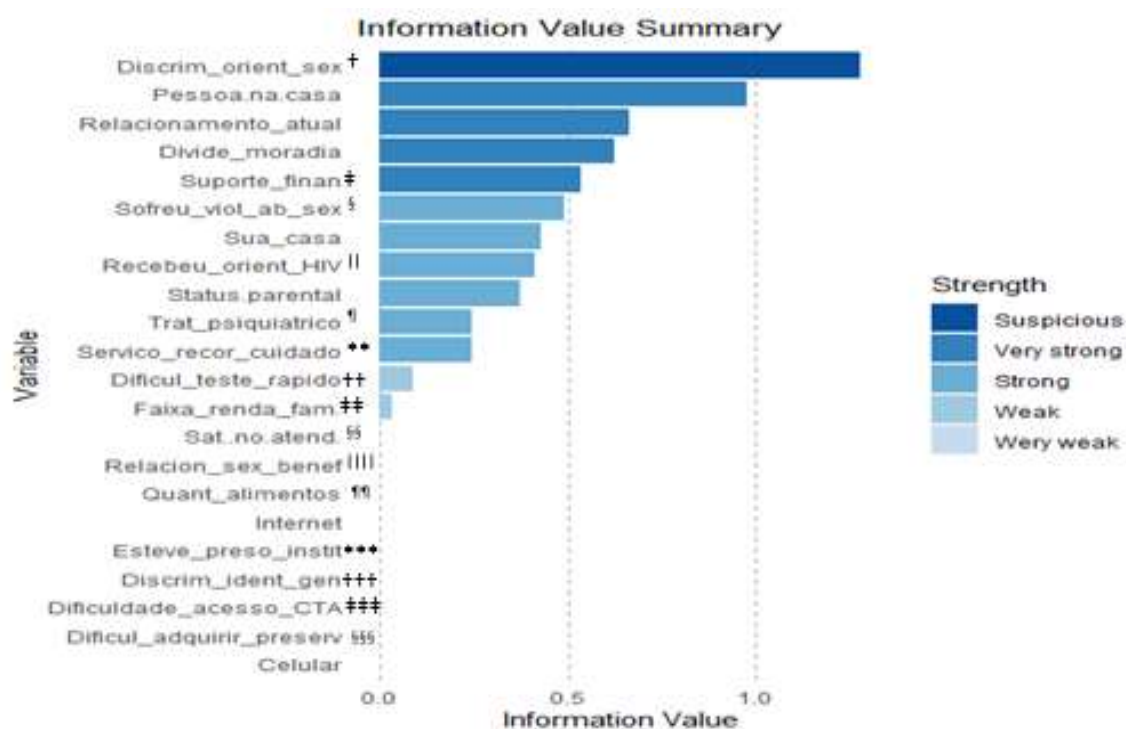
||Municipio _resid = Municipality of residence

Source: Own author

Figure 1: Classification of the informative value for sociodemographic variables according to the WoE* model. João Pessoa, PB, Brazil, 2021.

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Regarding Domain II, the variable "discrimination based on sexual orientation" demonstrated very strong/suspicious predictive power, while the social network variables—household members, current relationship, cohabitation, and financial support—showed very strong informational value, being considered relevant to explaining the serological outcome.



*WoE = Weight of Evidence; †Discrim_orient_sex = Discrimination based on sexual orientation; ‡Suporte_finan = Financial support; §Sofreu_viol_ab_sex = The person suffered sexual violence/abuse; ||Recebeu_orient_HIV = The person received guidance on the prevention of the Acquired Immunodeficiency Virus; ¶Trat_psiquiatrico = Psychiatric treatment; **Servico_recor_cuidado = Service accessed when a health situation requires care; ††Dificul_teste_rapido = Difficulty performing the rapid test; ‡‡Faixa_renda_fam = Family income bracket; §§Sat.no.atend = Customer service satisfaction; ||||Relacion_sex_benefet = Sexual relations in exchange for benefits; ¶¶Quant_alimentos = Amount of food; ***Esteve_preso_instit = The person was imprisoned or institutionalized; †††Discrim_ident_gen = Discrimination based on gender identity; ‡‡‡CTA = Testing and Counseling Center; §§§Dificul_adquirir_preserv = Difficulty obtaining condoms

Source: Author's own work.

Figure 2: Classification of the informative value for socio-structural variables according to the WoE* model. João Pessoa, PB, Brazil, 2021.

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Regarding domain III, evidence was observed that the variables: non-vaginal sex and use of illicit drugs, presented an informative value classified as very strong/suspicious. Furthermore, perceived risk of HIV infection, practice of insertive anal sex and age at first sexual intercourse also demonstrated high predictive power (very strong classification), indicating potential relevance for explaining the serological outcome in the population investigated.



*WoE = Weight of Evidence; [†]Uso_drog_ilicidas = Illicit drug use; [‡]HIV = Acquired Immunodeficiency Virus; [§]Idade_1a_relac_sex = Age at first sexual intercourse; ^{||}Relac_alg_soropos_HIV = Relationship with someone who is HIV-positive; [¶]Dificul_neg_preser_parceir = Difficulty negotiating condom use with a partner; ^{**}Frequen_uti_preserv = Frequency of condom use; ^{††}IST = Sexually Transmitted Infections; ^{‡‡}Status_sorol_parceir = Partner's serostatus; ^{§§}SCORE_pratica_sex = Sexual practices score; ^{||||}Uso_med_ant_exp_ris_HIV = Use of post-exposure prophylaxis method; ^{¶¶}Uso_med_ant_exp_ric_HIV = Use of pre-exposure prophylaxis method; ^{***}Primeira_relac_consent = First consensual sexual date; ^{†††}Ingere_beb_alc = The person drinks alcoholic beverage.

Source: Own authorship.

Figure 3: Classification of information value for behavioral variables according to the WoE* model. João Pessoa, PB, Brazil, 2021.

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DISCUSSION

The results demonstrated that sociodemographic, socio-structural, and behavioral factors significantly influence HIV infection among the young people studied. In the sociodemographic domain, sex and sexual orientation showed a significant association with serological status—a finding corroborated by the Weight of Evidence (WoE) model—with the notable observation that all reactive rapid tests occurred among men who have sex with men (MSM). In the socio-structural domain, discrimination based on sexual orientation and housing conditions emerged as relevant determinants, highlighting the impact of stigma, violence, and social inequalities on the creation of health vulnerabilities and inequities. Regarding the behavioral domain, higher-risk sexual practices, perceived risk of HIV acquisition, illicit drug use, and insertive anal sex were identified as key predictors of infection, reinforcing that the epidemic's dynamics are strongly linked to the interplay of individual, social, and structural factors that heighten this population's vulnerability.

In the first domain of the instrument (sociodemographic), it was found that the variables sex and sexual orientation were significant in Fisher's exact test. In this case, there was perfect agreement with the WoE in which both variables had greater weight of evidence in association with the outcome. In turn, the variables gender identity and race/color were included in the model because they demonstrate predictive influence in relation to the serological outcome, with very strong and strong association strength, respectively.

In 2022, the sexual orientation Men who have sex with men (MSM) accounted for 45.2% of cases diagnosed with HIV ⁶, whose prevalence is consistent with the results found in this research in which 100% of the rapid reagent tests were in MSM with male gender identity. Historically, men are more affected by the infection than women, so it is possible to say that they are more exposed to risk factors.

In the same year, the sex ratio was 28 men for every 10 women, highlighting the disproportionality with which men are more affected by HIV ⁶. Indeed, male gender can significantly influence HIV infection, particularly when inconsistent condom use is considered a vulnerability-increasing practice among the MSM population.^{22,27-29}.

Regarding factors associated with the socio-structural domain, it was observed that the variables discrimination due to sexual orientation and housing division were significant in both Fischer's exact test and the WoE model. Violence resulting from intolerance towards

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sexual orientation is structural and frequently occurs in schools, families, work, health services and society^{22,32-34}.

The deleterious effects of these actions have negative repercussions on health, both physical and emotional.³²⁻³³, given that practices of discrimination and violence are not uncommon and inevitably render victims vulnerable by creating barriers to accessing health services³⁵, in risky sexual behavior, in the use of psychoactive substances such as alcohol and other drugs^{22,36} and increase the chances of contracting STIs³⁴. Stigma and discrimination are significant barriers to the engagement of the MSM population in prevention efforts.^{25,37} and for the treatment of HIV infection^{25,38}.

The vulnerabilities produced by deficiencies and/or absences of public policies are responsible for maintaining the high burden of HIV and disproportionately affecting the most susceptible and marginalized social segments²⁷⁻²⁹.

Issues related to stigma, prejudice, discrimination, violence (sociocultural factors) and housing (socioeconomic factor) are inserted in the sociostructural context and are associated with the production of health inequities⁴⁰. Therefore, well-designed and articulated socio-structural interventions can produce effective responses to mitigate these weaknesses and control the epidemic.²⁷⁻²⁹.

In the behavioral domain, the variables "non-vaginal sex" and "risk of HIV acquisition" were found to be significant in Fisher's exact test, thus aligning with the WoE model. However, model analyses revealed that the variables "illicit drug use" and "insertive anal sex" were strong predictors associated with HIV infection ($IV > 0.5$). The WoE model also identified two additional variables influencing the dependent variable.

Engaging in high-risk sexual behavior is intrinsically linked to a distorted perception of risk, which hinders the adoption of strategies to mitigate vulnerabilities and enhance health-protective factors. Among men who have sex with men (MSM), the lack of perceived risk regarding HIV acquisition is concerning, as infection rates are rising in this population; this highlights both individual shortcomings (compromised prevention efforts) and socio-structural failures (weaknesses in public policy) in HIV control.^{22,26-27,29,36-37}.

In addition to the risks inherent in behavioral practices, the use of alcohol and other drugs is also a predictive factor that renders individuals vulnerable to the risk of contracting HIV, as cognitive perception is impaired, thereby hindering the ability to make conscious and appropriate decisions.^{22,36}.

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Despite scientific advances in combating HIV infection, many people still lack access to prevention and treatment strategies—particularly key and priority populations, whose specific needs require a tailored approach. Regarding the youth population, it is essential to understand their needs in order to provide comprehensive support and care, thereby addressing existing gaps.

These needs must be combined with other available strategies to reach the greatest number of young people and be able to produce safe behavioral changes. Sexual and reproductive health education, especially among peers, has proven to be an essential tool for HIV prevention. Through the educational approach, it is possible to discuss topics about awareness of infection prevention, promote a permanent space for dialogue, exchange of experiences and clarification of doubts, demystify mistaken concepts about HIV, discrimination, stigma and prejudice. In this scenario, the essential role of the school as a space for transformation and social inclusion stands out.⁴¹.

Based on the study's findings, the authors maintain that achieving more promising results in combating HIV infection among the youth population requires an understanding that the issue is complex and multifaceted, necessitating a joint analysis of the interplay between sociodemographic, behavioral, and—above all—structural factors. The seroprevalence found in the study corroborates those described in national and international literature, indicating that vulnerable populations, especially MSM (men who have sex with men), are more affected.^{20,23-27,34-36}, remain disproportionately more exposed to the risk of infection, particularly in a scenario marked by social inequalities, stigma, and barriers to accessing health services.^{3,11,14,30}.

Therefore, the findings reinforce that effective responses to HIV require the adoption of combined prevention strategies coordinated across different sectors of society, as well as the formulation of public policies that are sensitive to the specific needs of the most vulnerable populations and guided by SUS principles—particularly equity and comprehensiveness. Thus, the study contributes by highlighting the importance of understanding the synergy of contexts that render young people vulnerable, providing insights for improving interventions and formulating public policies that are more effective in expanding access to HIV prevention strategies.

Regarding the study's limitations, the cross-sectional design did not allow for the establishment of causal links between the independent variables and the dependent variable.

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Furthermore, the COVID-19 pandemic imposed certain restrictions on the data collection phase, such as low user demand for the service, the limitation of having only one researcher collecting data per shift, and the service's restricted operating hours. It must also be noted that the study's findings reflect the specificities of a local setting; therefore, they may be subject to bias if applied to contexts with different HIV infection trends among the youth population.

CONCLUSION

In this study, it is evident that the variables sex, sexual orientation, gender identity, race/color, discrimination based on sexual orientation and housing, non-vaginal sex, the risk of acquiring HIV, the use of illicit drugs and insertive anal sexual practice were predictors of HIV infection in the studied population.

It is noteworthy that HIV prevention strategies must consider the barriers imposed by the interaction between sociodemographic, behavioral and sociostructural factors, which are widely recognized but still difficult to overcome. In this context, the transformation of socio-structural determinants is a central element for the effectiveness of health interventions, since only approaches that transcend the individual level and face social inequalities, stigmas and limitations in access to services will be able to produce sustainable responses.

Thus, tackling these dimensions constitutes an essential condition for strengthening public prevention policies, contributing to consistent advances in controlling the HIV epidemic and promoting equity and quality of life.

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