



Temporal trend and epidemiological profile of HIV/AIDS in municipalities of the Bioceanic Route, Mato Grosso do Sul, 2010–2023

Tendência temporal e perfil epidemiológico do HIV/AIDS em municípios da Rota Bioceânica, Mato Grosso do Sul, 2010–2023

Tendencia temporal y perfil epidemiológico del VIH/SIDA en municipios de la Ruta Bioceánica, Mato Grosso do Sul, 2010–2023

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Abstract: Areas of intense migratory flow and industrial expansion present greater vulnerability to sexually transmitted infections, fostering their spread along commercial routes. Against this backdrop, this study analyzed the temporal trend and epidemiological profile of HIV in municipalities of Mato Grosso do Sul located along the Bioceanic Route (2010-2023). Specifically, temporal analyses of HIV rates were performed using data from the Notifiable Diseases Information System and the Brazilian Institute of Geography and Statistics. Additionally, we evaluated sociodemographic profiles and modes of transmission. Our results indicated an increase in HIV rates in Bataguassu, Guia Lopes da Laguna, Nioaque, Ribas do Rio Pardo, Santa Rita do Pardo, and Sidrolândia. In contrast, municipalities such as Campo Grande, Jardim, and Três Lagoas exhibited recent declining trends, possibly associated with the expansion of pre-exposure prophylaxis. Further analysis revealed that most cases occurred among males, with median ages ranging from 30 to 41 years, and a higher frequency of individuals who self-identified as brown in ethnicity. The most common probable mode of transmission was male-to-male sexual contact. These findings highlight the epidemic's internalization within the state and reinforce the need for combined prevention policies tailored to the context of commercial routes.

Keywords: HIV/AIDS; Epidemiology; Temporal trend; Public health; Bioceanic Route

Resumo: Áreas de intenso fluxo migratório e expansão industrial apresentam maior vulnerabilidade às infecções sexualmente transmissíveis, favorecendo sua disseminação em rotas comerciais. Este estudo analisou a tendência temporal e o perfil epidemiológico do HIV em municípios de Mato Grosso do Sul localizados na Rota Bioceânica (2010-2023). Foram feitas análises temporais das taxas de HIV a partir de dados do Sistema de Informação de Agravos de Notificação e do Instituto Brasileiro de Geografia e Estatística, e avaliação do perfil sociodemográfico e dos modos de transmissão. As taxas apresentaram tendência crescente em Bataguassu, Guia Lopes da Laguna, Nioaque, Ribas do Rio Pardo, Santa Rita do Pardo e Sidrolândia. Em contrapartida, municípios como Campo Grande, Jardim e Três Lagoas mostraram tendência decrescente nos segmentos mais recentes, possivelmente associada à ampliação da profilaxia pré-exposição. Predominaram indivíduos do sexo masculino, com mediana de idade entre 30 e 41 anos, e maior frequência de pessoas pardas. O modo de transmissão mais comum foi a relação sexual entre homens. Os resultados evidenciam a interiorização da epidemia no estado e reforçam a necessidade de políticas de prevenção combinada adaptadas às rotas comerciais.

Palavras-chave: HIV/AIDS; Epidemiologia; Tendência temporal; Saúde pública; Rota Bioceânica.

Resumen: Las áreas con intenso flujo migratorio y expansión industrial presentan mayor vulnerabilidad a las infecciones de transmisión sexual, favoreciendo su diseminación en rutas comerciales. Este estudio analizó la tendencia temporal y el perfil epidemiológico del VIH en municipios de Mato Grosso do Sul ubicados en la Ruta Bioceánica (2010–2023). Se realizaron análisis temporales de las tasas de VIH con datos del Sistema de Información de Enfermedades de Notificación Obligatoria y del Instituto Brasileño de Geografía y Estadística,

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así como la evaluación del perfil sociodemográfico y de los modos de transmisión. Las tasas mostraron una tendencia creciente en Bataguassu, Guia Lopes da Laguna, Nioaque, Ribas do Rio Pardo, Santa Rita do Pardo y Sidrolândia. En contraste, municipios como Campo Grande, Jardim y Três Lagoas presentaron tendencias decrecientes en los segmentos más recientes, posiblemente asociadas a la expansión de la profilaxis preexposición. Predominaron los hombres, con una mediana de edad entre 30 y 41 años, y mayor frecuencia de personas autodeclaradas pardas. El modo de transmisión más común fue la relación sexual entre hombres. Los resultados evidencian la interiorización de la epidemia en el estado y refuerzan la necesidad de políticas de prevención combinada adaptadas al contexto de las rutas comerciales.

Palabras clave: VIH/SIDA; Epidemiología; Tendencia temporal; Salud pública; Ruta Bioceánica.

1 INTRODUCTION

The Bioceanic Corridor, a logistics corridor connecting Brazil, Paraguay, Argentina, and Chile to the Atlantic and Pacific Oceans, integrates Mato Grosso do Sul into a regional integration project with significant impacts on local development. Beyond its economic and strategic benefits, this initiative entails increased population mobility, the circulation of workers, and the intensification of commercial flow conditions that may heighten vulnerability to sexually transmitted infections (STIs), such as HIV/AIDS (A Brita *et al.*, 2023; Aquino; Félix, 2023).

In Brazil, the HIV/AIDS epidemic continues to pose a significant challenge. In 2023, 46,495 new HIV cases were reported, representing a 24.1% increase compared to 2020, with an annual average of 36,000 AIDS cases over the past five years. Mato Grosso do Sul stands out in this context, with an AIDS notification rate of 23.5 per 100,000 inhabitants – the fifth highest in the country – and an even higher rate in the state capital, Campo Grande, at 28.6 per 100,000 inhabitants. Additionally, underreporting in the state is estimated at approximately 47.3%, further underscoring the severity of the situation (Brazil, 2024).

The national epidemiological profile indicates a higher concentration of cases among young males, self-identified as Black, with low levels of education and income, as well as a high prevalence among men who have sex with men (MSM) and heterosexual women (Torres *et al.*, 2021). An increase in cases among older adults has also been observed, a phenomenon associated with factors such as widowhood, divorce, low educational attainment, reduced risk perception, and unprotected sexual practices. In the state of São Paulo alone, between 2012 and 2020, 3,070 disease-related deaths were recorded, with an average rate of 51.71 cases per 100,000 inhabitants (Souza *et al.*, 2023).

The literature indicates that large-scale infrastructure projects and processes of unplanned urbanization can facilitate the spread of sexually transmitted infections (STIs). In the central Amazon region, for example, the construction of Highway BR-163 was associated with migration, prostitution, injectable drug use, and increased exposure to violence, creating a context of rising AIDS cases in areas that had previously been less affected (Barcellos *et al.*, 2010). This precedent demonstrates that economic development, when not accompanied by effective public policies, may generate adverse impacts on public health.

Despite the strategic relevance of the Bioceanic Corridor for regional development, studies systematically assess the impacts of this process on the epidemiological dynamics of HIV/AIDS in small – and medium-sized municipalities remain scarce, particularly in border settings and contexts of high population mobility. Most existing analyses focus on state capitals or large urban centers, which limits the understanding of specific vulnerabilities associated with the epidemic's interiorization, intermunicipal and cross-border circulation, and the local capacity of health

services to respond. In this context, investigating the temporal evolution of HIV/AIDS and the epidemiological profile of cases in municipalities of Mato Grosso do Sul located along the corridor represents a necessary contribution to informing prevention strategies, territorial planning, and the formulation of public policies sensitive to the specificities of local development.

Accordingly, this study aimed to analyze the temporal trends and epidemiological profile of HIV/AIDS among adults residing in municipalities of Mato Grosso do Sul located along the Bioceanic Corridor between 2010 and 2023, considering sociodemographic variables and modes of transmission.

2 METHODS

Data were obtained from publicly available, open-access databases, including the Brazilian Notifiable Diseases Information System (SINAN) and the Brazilian Institute of Geography and Statistics (IBGE), covering the period from 2010 to 2023. Data collection consisted of extracting HIV/AIDS records corresponding to municipalities in Mato Grosso do Sul located along the Bioceanic Corridor. Following extraction, the data underwent an initial process of organization and filtering using electronic spreadsheets (Microsoft Excel®), during which variables of interest were selected, including municipality of notification, year of notification, sex, age, race/color, and probable mode of transmission. HIV incidence rates were calculated using the formula: number of HIV cases/population × 100,000. The selected period enabled the assessment of temporal trends in notifications across municipalities. To this end, the JoinPoint Regression Program (version 5.3.0), developed by the National Cancer Institute (NCI, USA), was applied. This software identifies statistically significant changes in trends over time by estimating the Annual Percent Change (APC). Positive APC values indicate increasing trends, whereas negative values indicate decreasing trends.

Analyses of sociodemographic variables were conducted using R software, version 4.4.2 (R Core Team, 2024). After the data organization and filtering stage, the unified dataset was imported into the R environment for further processing. To assess the distribution of the Race and Sex variables in each municipality, absolute and relative frequencies (%) were calculated. Given the epidemiological relevance of these variables as potential social and behavioral determinants of HIV infection risk, the homogeneity of their distributions within each municipality was evaluated. Accordingly, the chi-square goodness-of-fit test was applied to examine whether the observed proportions differed from a uniform distribution. In municipalities with sample sizes smaller than 20 individuals, the chi-square test with Monte Carlo simulation (10,000 replications) was used to obtain more robust p-value estimates, accounting for the limitations of small samples and categories with low expected frequencies. In municipalities with samples of 20 cases or more, the classical chi-square test was applied, with exact calculation of the test statistic. Results were summarized in tables, and p-values below 0.05 were considered indicative of statistically significant differences between the observed proportions and the expected distribution. All analytical procedures were performed using the dplyr package (Wickham *et al.*, 2023) for data organization and manipulation, along with native R functions for statistical testing.

Age was considered in complete years, as recorded in the SINAN database. To characterize the age profile of cases, age was described using the median (M), mean, and standard deviation ($\bar{x} \pm SD$), allowing the assessment of both central tendency and dispersion of values in each

municipality. Age was not categorized into age groups, as the objective was to preserve data variability and avoid loss of analytical precision.

A multinomial logistic regression model was fitted to estimate the association of sex, age, and race with the probable mode of HIV transmission. In this model, age was included as a continuous variable. The outcome was categorized as “Sexual intercourse with women” (reference), “Sexual intercourse with men,” “Sexual intercourse with men and women,” “Unknown,” and “non-sexual transmission.” Cases with missing information were excluded (final $n = 5,374$). Odds ratios (ORs) and their corresponding 95% confidence intervals (95% CIs) were calculated. Model fitting was performed using the *nnet* package in R, version 4.4.2

Submission to a Research Ethics Committee was not required because the study exclusively used secondary data from publicly accessible sources with no possibility of individual identification, in accordance with Resolution No. 510/2016 of the Brazilian National Health Council.

3 RESULTS

A total of 12 municipalities were analyzed, comprising 4,020 HIV cases among adults. Sample sizes varied across municipalities, with Campo Grande accounting for most cases ($n = 3,267$), followed by Três Lagoas ($n = 533$) and Jardim ($n = 87$). In the remaining municipalities, case counts ranged from 5 to 63. According to Table 1, temporal trend analysis indicated increasing HIV rates among adults in Bataguassu, Guia Lopes da Laguna, Ribas do Rio Pardo, and Sidrolândia throughout the entire study period. Água Clara, Jardim, Porto Murtinho, Campo Grande, and Três Lagoas exhibited segments characterized by increases followed by declines in rates. Nova Alvorada do Sul showed no significant variations over the study period, whereas Santa Rita do Pardo displayed an increasing trend starting in 2020.

Table 1 – Temporal Trends in HIV Rates in Municipalities of the Bioceanic Corridor, Mato Grosso do Sul, 2010–2023

City	Segment	APC	95% CI	Classification
Água Clara	2010-2018	14,6*	5;75,9	Increasing
	2018-2023	-24,78*	-67,9;-8,3	Decreasing
Bataguassu	2010-2023	14,4*	7,6;25,8	Increasing
Campo Grande	2010-2014	335,9*	167,5;13548,1	Increasing
	2014-2018	16,9*	5,8;54,4*	Increasing
	2018-2023	-4,5	-22,9;2	-
Guia Lopes da Laguna	2010-2023	15,6*	9,4;26,4	Increasing
Jardim	2010-2015	71,2*	30,1;575,7	Increasing
	2015-2023	-15,9*	-34,4;-6,4	Decreasing
Nioaque	2010-2023	6,1*	0,9;12,3	Increasing
Nova Alvorada do Sul	2010-2023	3,9	-4,6;15,9	-
	2010-2013	-25,3	-62,4;11,1	-
Porto Murtinho	2013-2018	47,7*	26,9;126,2	Increasing
	2018-2023	-19*	-40;-6,4	Decreasing
Ribas do Rio Pardo	2010-2023	12,7*	4,1;28,2	Increasing
Santa Rita do Pardo	2010-2020	0,6	-14,4;8,5	-
	2020-2023	78,5*	32;192,5	Increasing
Sidrolândia	2010-2023	13,4*	7,9;22,2	Increasing

City	Segment	APC	95% CI	Classification
Três Lagoas	2010-2017	130*	73,7;2493,9	Increasing
	2017-2023	-13,8	-36,9;-0,4	Decreasing

Note: Values represent the Annual Percent Change (APC) with their respective 95% confidence intervals (95% CI). Trends were classified as increasing or decreasing based on statistical significance ($p < 0.05$), indicated by the asterisk (*).

Source: Prepared by the authors, based on data obtained from SINAN and population projections from IBGE.

From 2010 to 2023, variation in adult HIV rates was observed across municipalities located along the Bioceanic and cellulose corridors in Mato Grosso do Sul. Campo Grande consistently presented the highest rates over the period, exceeding 40 cases per 100,000 inhabitants from 2017 onward, reaching 46.9 in 2018 (415 cases) and remaining at elevated levels through 2023 (38.2; 343 cases). Três Lagoas also showed an increase, peaking at 105.6 in 2017 (124 cases) and 65.8 in 2022 (87 cases). Municipalities such as Guia Lopes da Laguna, Jardim, Ribas do Rio Pardo, Santa Rita do Pardo, and Sidrolândia exhibited rising rates in more recent years. Santa Rita do Pardo shifted from zero values through 2021 to 56.9 in 2022 (4 cases) and 42.7 in 2023 (3 cases). In contrast, Água Clara, Nova Alvorada do Sul, and Porto Murtinho maintained low values or reported no cases in several years. Bataguassu showed an increase beginning in 2019, with a peak in 2022 (21.7; 5 cases). In 2023, Campo Grande recorded the highest absolute number of cases (343), followed by Três Lagoas (43) and Sidrolândia (11). The highest rates per 100,000 inhabitants in the same year were observed in Santa Rita do Pardo (42.7), Guia Lopes da Laguna (40.2), and Ribas do Rio Pardo (34.6).

Analysis of the sex distribution revealed a predominance of males in most of the municipalities investigated. In Campo Grande ($n = 3,266$; $p < 0.001$) and Três Lagoas ($n = 533$; $p < 0.001$), significant differences between the proportions of men and women were observed, indicating a heterogeneous distribution relative to the hypothesis of equal probability between sexes. A similar result was found in Jardim ($n = 87$; $p < 0.001$), reinforcing the trend toward a higher proportion of cases among men in municipalities with larger numbers of records.

Overall, in municipalities with smaller numbers of records, no differences were observed in the proportions of cases by sex ($p > 0.05$). In Nova Alvorada do Sul ($n = 14$; $p = 0.056$), although the proportion of men was higher than that of women, the test did not indicate a statistically significant difference according to the adopted criterion. A similar pattern was observed in Água Clara, Bataguassu, Guia Lopes da Laguna, Nioaque, Porto Murtinho, Ribas do Rio Pardo, Santa Rita do Pardo, and Sidrolândia. It should be noted that in some of these municipalities, the small sample size may limit the statistical power of the test. In Porto Murtinho specifically, an exactly balanced distribution between sexes was observed, with 50% male and 50% female cases.

The median age ranged from 30 years (Santa Rita do Pardo and Campo Grande) to 41 years (Guia Lopes da Laguna), indicating variability in the age profile across municipalities. Male individuals predominated in most municipalities, with proportions ranging from 50% (Porto Murtinho) to 78.6% (Nova Alvorada do Sul). Only in Guia Lopes da Laguna was a higher frequency of women observed (72.7%).

Analysis of the race variable indicated non-homogeneous distributions across several municipalities. In Campo Grande ($n = 3,252$), the White category was the most frequent, accounting for 47% of records, followed by Brown/mixed race (37.1%). In Três Lagoas ($n = 531$), the

Brown/mixed race category predominated (54.4%), with a lower proportion of White individuals (33.4%). In Jardim ($n = 87$) and Sidrolândia ($n = 61$), the Brown/mixed race category also showed the highest frequency, representing 66.7% and 54% of cases, respectively. In municipalities with smaller case counts, a predominance of the Brown/mixed race category was observed in Ribas do Rio Pardo (60%), Nova Alvorada do Sul (64.3%), and Guia Lopes da Laguna (72.7%). In Porto Murtinho ($n = 20$), most records were from individuals self-identified as White (55%). In the remaining municipalities—Água Clara, Bataguassu, Nioaque, and Santa Rita do Pardo—the distribution across race categories was more balanced or did not show consistent differences, considering the small sample sizes in these locations.

Table 2 – Sociodemographic Characteristics of HIV Cases among Municipalities of the Bioceanic Corridor, 2010–2023

City	No. of cases	Age		Sex		Race					
		M	Mean \pm SD	Female	Male	White	Black	Asian	Brown/mixed race	Indigenous	Unknow
Água Clara	5	38	41,2 (19,1)	3 (60%)	2 (40%)	1 (20%)	1 (20%)	0 (0%)	2 (40%)	0 (0%)	1 (20%)
Bataguassu	14	39	39,8 (12,5)	6 (42,9%)	8 (57,1%)	4 (28,6%)	2 (14,3%)	1 (7,1%)	5 (35,7%)	0 (0%)	2 (14,3%)
Campo Grande	3.267	30	32,7 (11,5)	766 (23,4%)	2.500 (76,5%)*	1.534 (47%)*	263 (8,1%)	173 (5,3%)	1211 (37,1%)	15 (0,5%)	71 (2,2%)
Guia Lopes da Laguna	11	41	40,5 (12,9)	8 (72,7%)	3 (27,3%)	2 (18,2%)	1 (9,1%)	0 (0%)	8 (72,7%)*	0 (0%)	0 (0%)
Jardim	87	32	34,3 (14,5)	41 (47,1%)	46 (52,9%)*	26 (29,9%)	1 (1,1%)	0 (0%)	58 (66,7%)*	0 (0%)	2 (2,3%)
Nioaque	7	38	36,9 (14,4)	2 (28,6%)	5 (71,4%)	1 (14,3%)	0 (0%)	0 (0%)	3 (42,9%)	3 (42,9%)	0 (0%)
Nova Alvorada do Sul	14	39	37,5 (12,8)	3 (21,4%)	11 (78,6%)	3 (21,4%)	1 (7,1%)	0 (0%)	9 (64,3%)*	0 (0%)	1 (7,1%)
Porto Murtinho	20	34,5	33,2 (11,1)	10 (50%)	10 (50%)	11 (55%)*	2 (10%)	0 (0%)	7 (35%)	0 (0%)	0 (0%)
Ribas do Rio Pardo	25	34,5	36,5 (14,2)	9 (36%)	16 (64%)	8 (32%)	1 (4%)	0 (0%)	15 (60%)*	0 (0%)	1 (4%)
Santa Rita do Pardo	7	30	40 (19,8)	2 (28,6%)	5 (71,4%)	2 (28,6%)	0 (0%)	0 (0%)	4 (57,1%)	0 (0%)	1 (14,3%)
Sidrolândia	63	34	37,5 (13,6)	31 (49,2%)	32 (50,8%)	17 (27%)	8 (12,7%)	0 (0%)	34 (54%)*	3 (4,8%)	1 (1,6%)
Três Lagoas	533	32	34,6 (12,1)	175 (32,8%)	358 (67,2%)*	178 (33,4%)	47 (8,8%)	4 (0,8%)	290 (54,4%)*	2 (0,4%)	12 (2,3%)

Note: *M* = median; mean \pm SD = mean and standard deviation. Values are expressed as absolute and relative frequencies (%). The asterisk (*) indicates a statistically significant difference in the distribution (chi-square goodness-of-fit test, $p < 0.05$).

Source: Prepared by the authors (2025), based on data from SINAN.

Overall, the probable mode of HIV transmission showed a predominance of men who have sex with men (MSM), particularly in municipalities with higher numbers of records. This pattern was consistently observed in the main urban centers included in the study, indicating a concentration of cases within this exposure category.

When analyzing municipalities individually, Campo Grande showed 58.0% of cases attributed to MSM, followed by Três Lagoas (56.7%), Jardim (59.8%), and Sidrolândia (54.0%). In these municipalities, the distribution across categories of probable mode of transmission differed from the equiprobability pattern ($p < 0.05$), indicating a greater concentration of cases in this

category. In the remaining municipalities, the distribution of transmission modes appeared more balanced, even when an apparent predominance of a single category was observed. For example, in Guia Lopes da Laguna (63.6%), Porto Murtinho (50.0%), and Água Clara (60.0%), the test did not indicate statistically significant differences according to the adopted criterion, considering the available sample sizes.

In Nioaque, Bataguassu, Nova Alvorada do Sul, and Santa Rita do Pardo, higher proportions were observed for the categories “sexual intercourse with women” or “unknown,” with no evidence of a marked concentration among the evaluated options. It should be noted that in these municipalities, the small number of records limits more robust inferences regarding transmission patterns.

In the multinomial logistic regression model, men showed a higher likelihood of belonging to the category “sexual intercourse with men” as the probable mode of transmission, compared with the reference category “sexual intercourse with women” (OR = 0.01; 95% CI: 0.0057–0.0137). For the category “sexual intercourse with men and women,” a lower association with male sex was observed (OR = 0.27; 95% CI: 0.12–0.59). The age variable showed little variation across the evaluated categories, and race/color did not present meaningful associations in the adjusted model.

4 DISCUSSION

The study identified distinct temporal trends in HIV rates across municipalities of Mato Grosso do Sul located along the Bioceanic Corridor. Increasing trends were observed in small- and medium-sized municipalities such as Bataguassu, Guia Lopes da Laguna, Ribas do Rio Pardo, Sidrolândia, and Santa Rita do Pardo, whereas Campo Grande and Três Lagoas accounted for the highest absolute numbers of cases, with fluctuations over the historical series. In smaller municipalities, such as Santa Rita do Pardo, elevated rates per 100,000 inhabitants were observed in specific years, suggesting the occurrence of localized outbreaks. Regarding the sociodemographic profile, cases were predominantly among men, with median ages ranging from 30 to 41 years, and a higher frequency of the Brown/mixed race category in several municipalities. With respect to the probable mode of transmission, sexual exposure among MSM was the most frequent, particularly in cities with larger numbers of records.

Increases in HIV cases have been associated with population density and the process of urbanization and have been shown to be inversely related to gross domestic product (Ren *et al.*, 2022). Consistent with this pattern, the most populous cities—Campo Grande and Três Lagoas—concentrated the highest absolute numbers of cases. A similar dynamic was observed in a study of Brazilian MSM, in which state capitals such as São Paulo and Porto Alegre exhibited a higher prevalence of hepatitis C, even in contexts of higher average educational attainment and expanded access to information and testing. This finding was attributed to greater population circulation, expansion of sexual networks, and the adoption of risk practices, such as multiple sexual partners, unprotected anal intercourse, and drug use (Silva *et al.*, 2023).

Another hypothesis for this phenomenon is the greater diagnostic and reporting capacity in large urban centers, which allows the identification of cases that may have been previously underreported. A study on primary health care across 5,570 Brazilian municipalities demonstrated significant structural shortcomings, such as insufficient availability of rapid tests, lack of prevention

supplies – including male and female condoms – and health care teams rated as regular or poor (Santos *et al.*, 2021). This reality, which remains present in many medium- and small-sized cities, not only favors underreporting but also compromises prevention efforts and timely treatment.

In the municipalities of Três Lagoas and Jardim, the APC showed a decreasing trend in the most recent segments, including 2023. In Campo Grande, although the reduction did not reach statistical significance, a decline was also observed in the final period of the series. This pattern may be related to the expansion of access to pre-exposure prophylaxis (PrEP), whose dispensing is already well established in all three municipalities. Conversely, in locations that also exhibited decreasing trends, such as Porto Murtinho and Água Clara, there are no records of PrEP availability. In these contexts, it is plausible to assume that individuals at higher risk were referred to neighboring municipalities where prophylaxis is available, such as Jardim and Três Lagoas, which may have contributed to the observed reduction in cases.

PrEP represents one of the most effective strategies for reducing new HIV infections among key populations. Evidence supporting this effectiveness was provided by a multicenter study conducted in São Paulo and Rio de Janeiro between 2014 and 2016, which followed 450 participants – MSM and transgender women. After 48 weeks, 83% remained in follow-up, and approximately 74% achieved protective drug concentrations consistent with regular medication use. During this period, HIV incidence was extremely low, and the two seroconversions recorded occurred exclusively among individuals who were not adherent to the PrEP regimen (Grinsztejn *et al.*, 2018). In addition to demonstrating the effectiveness of PrEP in high-vulnerability settings, the study also highlighted social benefits reported by users, such as increased valuation of self-care and improvements in interpersonal relationships.

These findings confirm that sustained adherence is the primary determinant of PrEP effectiveness and directly align with the results observed in this study. The decreasing trend identified in municipalities such as Três Lagoas, Jardim, and, to a lesser extent, Campo Grande supports the hypothesis that the expansion of access to and consolidation of PrEP dispensing in these locations have contributed to the recent reduction in new cases. In this context, policies aimed at ongoing support and continuous monitoring are essential to maximize this effect and ensure the maintenance of the prophylaxis's protective impact.

The temporal analysis of HIV cases in municipalities located along commercial routes in Mato Grosso do Sul suggests a positive correlation between intensified labor mobility and increased notifications. In contrast, a study conducted in China identified a negative association between commercial passenger traffic and STI notifications from 2013 to 2019, indicating that greater circulation was associated with a reduction in cases (Xia *et al.*, 2024). This discrepancy may reflect factors such as improved access to diagnostic services, more effective local interventions, and distinct patterns of population mobility.

The median age ranged from 30 to 41 years, confirming that adults accounted for most cases. This profile is similar to that reported in other studies, in which adults aged 25 to 37 years showed a higher prevalence of HIV (Brignol *et al.*, 2016; Gogela *et al.*, 2018; Silva *et al.*, 2022). A greater propensity for risk behaviors—such as condomless sex, multiple sexual partners, early sexual debut, and sexual practices associated with alcohol and drug use—may explain part of this finding (Brignol *et al.*, 2016; Wilson *et al.*, 2021). Other contributing factors include limited access to information and lower risk perception among young people, particularly men in areas of greater economic circulation, who tend to show less concern about prevention compared

with older individuals (Wilson *et al.*, 2021).

Similar findings were reported by Zhu *et al.* (2019), who observed a median age of 36 years among participants, approximately 80% of whom had not completed primary education. In that study, non-use of condoms with steady partners and inconsistent use with casual partners were predominant. In addition, age over 50 years was associated with an eightfold higher risk of infection. Santos (Santos *et al.*, 2018), in a study of truck drivers, found high levels of knowledge about STIs but low adherence to safe practices, even in the presence of free condom distribution. These results reinforce that information alone does not guarantee consistent behavioral change. In the present analysis, it was not possible to assess the education variable due to limitations inherent to the use of secondary data, as records for this information were incomplete or missing.

The racial analysis revealed heterogeneity across the municipalities studied. In Campo Grande, the White population predominated, whereas in Três Lagoas and Jardim the largest proportion consisted of Brown/mixed race individuals. In smaller municipalities, such as Ribas do Rio Pardo and Nova Alvorada do Sul, the Brown/mixed race population also predominated, with the exception of Porto Murtinho, where a predominance of White individuals was observed. These differences may reflect both local demographic characteristics and inequalities in access to health services and diagnostic testing. The findings partially corroborate national studies indicating a higher occurrence of STIs among Black and Brown/mixed race populations (Brignol *et al.*, 2016; De Amorim *et al.*, 2018; Torres *et al.*, 2021). The predominance of cases among White individuals in the state capital may be related to unequal access to information and testing. A similar pattern was observed in a study on hepatitis C prevalence, in which higher frequencies occurred among White individuals, primarily concentrated in large urban centers (Silva *et al.*, 2023).

Among the cases analyzed, a predominance of sexual transmission among MSM was observed, particularly in municipalities with the highest absolute numbers of records: Campo Grande (58.0%), Três Lagoas (56.7%), and Jardim (59.8%). These results highlight the concentration of the epidemic among MSM, confirming the high vulnerability of this group, in line with findings indicating a substantially higher prevalence of syphilis—approximately 18 times higher among men and 3.5 times higher among MSM (Benitez *et al.*, 2023). Behavioral characteristics that increase susceptibility in this group include a higher number of sexual partners compared with heterosexual individuals, inconsistent condom use during anal and oral sex, absence of a steady partner, and sexual activity under the influence of drugs (Benitez *et al.*, 2023; Torres *et al.*, 2021; Gogela *et al.*, 2018).

Conversely, a comparative study showed that MSM reports a higher frequency of consistent condom use than heterosexual individuals, although STI rates remain high in this population (Pilecco *et al.*, 2025). Beyond behavioral factors, structural elements such as discrimination, gaps in access to sexual health services, and low income also contribute to the persistence of vulnerability in this group (Brignol *et al.*, 2016; Silva *et al.*, 2022; Torres *et al.*, 2021).

Although not specified in secondary data, the literature identifies several risk groups for the HIV epidemic, particularly in regions of greater economic development, such as border areas and commercial routes. Truck drivers, due to frequent mobility, long periods away from home, and multiple sexual partners—even within stable relationships—constitute a particularly vulnerable group (Da Silva Busanello *et al.*, 2020). Despite having knowledge about STIs and their modes of transmission, this population shows low adherence to safe practices, with inconsistent condom use (Santos *et al.*, 2018). These behavioral patterns may facilitate the spread of HIV along commercial routes, reinforcing the importance of targeted policies focused on testing, condom

distribution, and sexual health education tailored to mobile workers.

Although the findings did not indicate a predominance of female cases, studies conducted in contexts involving sex workers demonstrate greater vulnerability among women in areas of economic development. This vulnerability is associated with exposure to multiple sexual partners, socioeconomic disadvantages, barriers to access to health services, irregular condom use, and low risk perception regarding HIV (Wilson *et al.*, 2021). This condition translates into higher rates of STIs among female sex workers compared with women who do not engage in this activity, even when residing in the same locality (Llangarí-Arizo *et al.*, 2024).

The spread of HIV in the municipalities analyzed appears to result from the interaction between individual factors – such as multiple sexual partners and unprotected anal intercourse – and structural factors, including urbanization, population density, and labor mobility. This pattern aligns with findings from national and international studies indicating that urban environments and circulation routes facilitate the expansion of HIV/AIDS and other STIs (Ren *et al.*, 2022; Silva *et al.*, 2023).

Municipalities that exhibited increasing APCs in segments including the year 2023—such as Bataguassu, Guia Lopes da Laguna, Nioaque, Nova Alvorada do Sul, Ribas do Rio Pardo, Santa Rita do Pardo, and Sidrolândia – are characterized by the presence of medium – and large-scale industrial activities, ranging from the agri-food sector to the production of cellulose, paper, and energy. In this context, Ribas do Rio Pardo stands out for hosting an operational cellulose plant, while Bataguassu is the site of a large-scale facility under construction in the same sector (Abrita *et al.*, 2023). The installation and expansion of these enterprises entail increased population inflows and worker mobility – factors that intensify social interactions and may facilitate the spread of sexually transmitted infections, including HIV. Accordingly, industrial concentration in these localities may be associated with the observed growth trends, reinforcing the need for targeted prevention strategies and epidemiological surveillance in contexts of intense economic activity.

This study has several limitations that should be considered when interpreting the results. The use of secondary data from SINAN is subject to underreporting, inconsistencies in data entry, and missing information for certain variables, such as education, which limits more in-depth analyses of individual socioeconomic determinants. In addition, the small number of cases in some municipalities reduced the statistical power of certain analyses, particularly those stratified by sex, race, or probable mode of transmission. Finally, the ecological study design precludes causal inferences at the individual level, as the observed associations reflect population-level and contextual patterns and should be interpreted in light of the territorial and structural characteristics of the municipalities analyzed.

Nevertheless, this study contributes to the understanding of HIV dynamics in municipalities characterized by intense population mobility and economic expansion by highlighting temporal trends and epidemiological profiles in contexts beyond major urban centers. The findings underscore specific vulnerabilities of small – and medium-sized municipalities located along the Bioceanic Corridor and provide evidence to support the planning of epidemiological surveillance and combined prevention strategies, particularly with regard to the expansion and decentralization of PrEP. By articulating public health and territorial development, the study reinforces the importance of integrated public policies that are sensitive to local specificities in addressing HIV.

5 CONCLUSIONS

The results indicate that the increase in HIV cases along commercial routes in Mato Grosso do Sul is associated with a combination of demographic, behavioral, and structural factors. The predominance of male individuals, racial and age-related heterogeneity, and the influence of labor mobility highlight the need for interventions tailored to local contexts. Specific populations, such as truck drivers and sex workers, although not directly analyzed in this study, warrant strategic attention, reinforcing the importance of combined prevention policies, expanded testing, and targeted sexual health education initiatives aimed at reducing HIV transmission and other sexually transmitted infections in the region.

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Data availability

The entire dataset supporting the results of this study has been published in the article itself.

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