Contextual factors associated with late HIV diagnosis in people aged 50 years and older in Brazil (2017–2022)

Fatores contextuais associados ao diagnóstico tardio de HIV em pessoas com 50 anos ou mais no Brasil (2017–2022)

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ABSTRACT

Introduction: Population aging has health implications beyond individual aspects. People aged 50 years or older may have a lower perception of risk, less access to preventive strategies, and greater structural vulnerability to late diagnosis, with negative impacts on clinical outcomes and quality of life. **Objective:** To identify social determinants associated with late diagnosis of HIV infection in people aged 50 years or older in Brazil. **Methods:** A cross-sectional ecological study with data from the federation units in the period from 2017 to 2022, using negative binomial regression modeling to estimate associations between socioeconomic variables and health access indicators with the proportion of late diagnosis (CD4<200 cells/mm^3). **Results:** 43,395 cases of HIV in people aged 50 years or older, 32.9% of them late. A statistically significant direct association was identified between late diagnosis of HIV and the illiteracy rate (RR>1), and inverse and significant associations with the aging rate and distribution of rapid tests (RR<0). In terms of population, these magnitudes represent substantial impacts on late diagnoses in the population aged 50 years or older. **Conclusion:** It was found that higher rates of illiteracy increase the occurrence of late diagnoses, while greater population aging and greater distribution of rapid tests reduce this risk.

Keywords: Late diagnosis. HIV infection. Aging. Linear models. Social determinants.

RESUMO

Introdução: O envelhecimento populacional apresenta implicações na saúde para além de aspectos individuais. Pessoas com 50 anos ou mais podem apresentar menor percepção de risco, menor acesso a estratégias preventivas e maior vulnerabilidade estrutural a diagnóstico tardio, com impactos negativos nos desfechos clínicos e na qualidade de vida. **Objetivo:** Identificar determinantes sociais associados ao diagnóstico tardio da infecção pelo HIV em pessoas com 50 anos ou mais no Brasil. **Métodos:** Estudo ecológico transversal com dados das unidades da federação no período de 2017 a 2022, utilizando modelagem de regressão binomial negativa para estimar associações entre variáveis socioeconômicas e indicadores de acesso à saúde com a proporção de diagnóstico tardio (CD4<200 células/mm^3). **Resultados:** Foram diagnosticados 43.395 casos de HIV em pessoas com 50 anos de idade ou mais, 32,9% deles, tardiamente. Identificou-se associação direta estatisticamente significativa do diagnóstico tardio de HIV e a taxa de analfabetismo (RT>1), e associações inversas e significativas com a taxa de envelhecimento e distribuição de testes rápidos (RT<0). Em termos populacionais, tais magnitudes representam substanciais impactos nos diagnósticos tardios na população com 50 anos ou mais. **Conclusão:** Identificou-se que taxas mais altas de analfabetismo aumentam a ocorrência de diagnósticos tardios, enquanto maior envelhecimento populacional e maior distribuição de testes rápidos reduzem esse risco. Esses achados reforçam a importância de políticas voltadas à educação em saúde, ampliação da testagem e redução de desigualdades para redução do diagnóstico tardio do HIV em adultos mais velhos.

Palavras-chave: Diagnóstico tardio. Infecção por HIV. Envelhecimento. Modelos lineares. Determinantes sociais.

INTRODUCTION

The epidemic caused by the human immunodeficiency virus (HIV) displays diverse epidemiological patterns, affecting different population groups. Advances in diagnosis, treatment, and public health policies have contributed to increased life expectancy and improved quality of life, along with substantial reductions in overall morbidity and mortality rates. However, more detailed analyses have revealed groups with heightened vulnerability to the risks of infection and illness [1,2].

In Brazil, data show a demographic aging trend that, in 2022, accounted for 10.9% of the total population—an increase of 57.4% compared to 2010, when this group represented 7.4% of the population[3]. This phenomenon entails behavioral and structural changes with important public health implications. Studies indicate that older adults have lower risk perception for sexually transmitted infections, reduced condom use, and limited access to prevention strategies—factors that contribute to greater exposure to infection as well as delayed presentation to health services[4]. Individuals diagnosed late face a higher risk of clinical complications and mortality, in addition to the potential for viral transmission.

Monitoring of late diagnosis is carried out through the measurement of cluster of differentiation 4 (CD4) lymphocyte counts. In Brazil, a count below 350 cells/mm³ is an indication for treatment of latent tuberculosis infection due to the increased susceptibility to this and other coinfections; a count below 200 cells/mm³, in turn, indicates an advanced stage of illness, which contributes to increased morbidity and mortality [2].

Clinical characteristics of HIV infection—such as its long latency period, absence of evident symptoms, increased vulnerability in this age group, and the stigma associated with HIV—may hinder timely

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diagnosis[5]. Additionally, it is noted that health professionals often request serologic testing only for older adults who are widowed, use drugs, or have multiple partners, while overlooking those in stable relationships. There is also a mistaken perception that older adults are asexual, which prevents adequate discussion of sexuality during clinical encounters and contributes to late diagnosis [6].

Late diagnosis affects treatment and quality of life among people living with HIV/AIDS (PLWHA). In individuals aged 50 years or older, it has been associated with worse clinical outcomes, including higher risk of comorbidities, disease progression, increased mortality, and higher treatment costs[7]. Studies suggest that contextual factors related to the social determinants of health—such as access to education, income, and health policies—play an important role in access to diagnosis[8,9].

Cases diagnosed late have shown an increasing trend. In Brazil, one study estimated a mortality rate of 16.5% in the first year after diagnosis among individuals who presented late to health services[10]. Research conducted in the Northeast region of the country found that 68.4% of patients-initiated treatment with a CD4 lymphocyte count below 200 cells/mm^3[11]. Recent data from the Ministry of Health indicate that, in 2024, 26.4% of PLWHA began antiretroviral therapy (ART) with CD4 counts below 200 cells/mm^3[12]. Globally, a similar situation is observed. A review of international studies showed that approximately 50% of individuals diagnosed with HIV present CD4 counts below 350 cells/mm^3 at the time of diagnosis [12].

Although individual factors play an important role, there is growing recognition of the relevance of contextual factors—such as socioeconomic indicators, distribution of health services, and public policies—in determining timely diagnosis. In this regard, ecological studies allow for the examination of these relationships at the population level by using territorial aggregates as units of analysis and incorporating variables that capture the broader social context beyond individual characteristics. Describing the contextual factors associated with late HIV diagnosis among people aged 50 years and older in Brazil can therefore support public health strategies aimed at expanding early diagnosis, reducing viral transmission, and improving the quality of life of this population.

OBJECTIVE

This article examines the relationship between contextual variables and cases of late HIV diagnosis among individuals aged 50 years and older in Brazil from 2017 to 2022. Its objective is to describe factors associated with social determinants and to identify potential associations, thereby contributing to the development of public policies that promote early diagnosis and improve clinical outcomes in this population.

METHODS

Study design and population

This was a cross-sectional ecological study based on data from the federative units (FUs) of Brazil between 2017 and 2022. The FUs were used as units of analysis to examine associations between contextual factors and the proportion of late HIV diagnoses among individuals aged 50 years and older, with the aim of identifying population-level patterns and regional inequalities relevant to health planning.

All reported cases of HIV infection among adult men and women aged 50 years or older in the 27 Brazilian FUs during the study period were included.

Data sources

Epidemiological data were obtained from the Notifiable Diseases Information System (NDIS)[13], and contextual data were retrieved from the databases of the United Nations Development Programme (UNDP)[14] and the Institute for Applied Economic Research (AER) [15]. Information on timely HIV diagnosis was obtained from monitoring data provided by the Brazilian Ministry of Health[16].

Study variables

The proportion of late HIV diagnosis is an indicator of unfavorable immune response and consequent disease progression, reflecting delayed presentation to health services. It consists of the proportion of individuals with CD4 counts below 200 cells/mm^3 among all PLWHA who underwent their first CD4 lymphocyte count test and had not yet initiated ART[5]. The contextual variables relate to social determinants and health-care access policies. The Human Development Index (HDI) is an indicator of development in terms of income, education, and health, ranging from 0 to 1, with higher values indicating more favorable development conditions[14]. The Gini Index[17], a measure of income distribution, and the Social Vulnerability Index (SVI)[18], which captures vulnerability in terms of income, housing, work, and employment, also range from 0 to 1, with higher values indicating more adverse conditions. The illiteracy rate refers to the proportion of individuals who report not being able to read or write; the aging rate reflects the proportion of older adults in a given locality[17]; and the proportion of distributed rapid HIV tests serves as a proxy indicator of access to diagnosis[16]. The contextual indicators used in this study correspond to each of Brazil's federative units for each year within the study period.

Statistical analysis

Descriptive analyses were performed to obtain summary measures of the study variables. Regression analyses were conducted using log-linear models, beginning with Poisson regression and subsequently employing negative binomial modeling after identifying overdispersion in the data[18].

To investigate the associations between late HIV diagnosis in individuals aged 50 years or older and the contextual variables, the model was specified with the logarithm of the mean occurrence of late diagnoses, $\log(\lambda)$, as the outcome variable—representing the numerator of the late diagnosis proportion. The denominator of this proportion, corresponding to the total number of PLWHA who underwent their first CD4 test, was included as an offset term to adjust the models according to the population at risk in each unit of analysis.

The contextual variables included in the model are represented by the β coefficients, whose exponentiation corresponds to the rate ratios (RR). Multicollinearity among variables was assessed using the Variance Inflation Factor (VIF), with tolerance for values below 10. Univariate models were fitted to assess the effect of each contextual variable on the outcome; variables with statistical significance and theoretical relevance were then included in the final multivariable model.

Model fit was evaluated using deviance residuals, comparing observed residual values to theoretical quantiles, with limits defined by the median and percentiles of simulated residuals. Analysis were conducted using R software[19], version 4.3.1, considering a 95% confidence interval (95% CI).

Ethical considerations

This study used publicly accessible, unrestricted, population--level data and was therefore exempt from review by a Research Ethics Committee [20].

RESULTS

During the study period, 43,395 cases of HIV infection were diagnosed among individuals aged 50 years or older in Brazil, of which 32.9% were classified as late diagnoses.

Table 1 presents the sociodemographic characteristics of the cases. A predominance of males is observed (63.3%), and most individuals were between 50 and 59 years of age (61.4%). The majority self--identified as Black (55.5% mixed-race) and had an elementary level of education (60.3%). The predominant route of transmission was sexual (98.3%). These characteristics highlight structural influences in the dynamics of HIV infection, particularly those related to access to education and health care, and underscore the important role of sexual experiences during aging.

The results of the exploratory analyses show that the contextual indicators exhibit substantial variation in magnitude (Table 2), with wide regional and contextual disparities throughout the study period. The HDI ranges from 0.631 to 0.854, with higher values in the Federal District, São Paulo, and Santa Catarina, and lower values in Maranhão, Alagoas, Amapá, and Piauí. In terms of inequality, the Gini Index varies between 0.420 and 0.666, indicating significant income disparity, with states in the North and Northeast regions showing less favorable values, while states in the South and Southeast show more advantageous levels. The SVI ranges from 0.123 to 0.372, reflecting different degrees of socioeconomic vulnerability, and the illiteracy rate—from 2.62% to 20.14%—reveals strong heterogeneity in access to education. With respect to the aging rate, values ranging from 4.14 to 13.47 highlight differences in age composition across the federative units. The proportion of rapid test distribution, which ranges from 0.278 to 17.49, indicates pronounced inequities in the availability of diagnostic testing.

The states in the Northern and Northeastern regions showed values indicative of less favorable conditions regarding human development, income distribution, and dimensions of vulnerability (Figure 1). The proportion of late diagnosis varied from 14% to 80% across Brazilian states, with annual fluctuations. In 2017, a high proportion of late diagnoses was observed in states in the North and Northeast, particularly Piauí (69%) and Acre (67%). In 2018, Rio Grande do Norte and Goiás reported a 54% proportion of late diagnoses. In Brazil overall, the proportion of late HIV diagnosis among individuals aged 50 years or older ranged from 43% to 45%, consistently higher than the proportions observed in the general population (between 26% and 28%) in all years of the study period.

These years were marked by lower testing coverage, especially in the Northern and Northeastern regions. In 2019, São Paulo was

Table 1. Sociodemographic characteristics of HIV/AIDS cases among individuals aged 50 years and older in Brazil (2017–2022).

Characteristics	n	%
Gender		
Male	27,470	63.3
Female	15,925	36.7
Age group		
50 to 59	28,784	61.4
60 to 69	11,375	24.3
70 to 79	2,678	5.7
80 and olders	563	1.2
Education level		
Elementary education	10,622	60.3
Secondary education	4,386	24.9
Higher education	1,843	10.5
Race/color		
White	9,746	43.4
Black	2,502	11.1
Brown	9,958	44.4
Other	221	1.1
Exposure category		
Sexual	18,647	98.3
Bloodborne	314	1.7

Table 2. Descriptive statistics of contextual socioeconomic development indicators in the federative units of Brazil (2017–2022).

	Minimun	1st quartile	Median	3st quartile	Maximun
Human Development Index (HDI)	0.631	0.700	0.733	0.772	0.854
Gini Index	0.420	0.494	0.530	0.565	0.666
Social Vulnerability Index (SVI)	0.123	0.217	0.270	0.299	0.372
Illiteracy rate	2.620	5.232	7.090	13.705	20.140
Aging rate	4.140	7.110	8.815	9.602	13.470
Proportion of rapid HIV test distribution	0.278	1.220	2.247	5.097	17.490

the state with the highest testing coverage across all years of the study. The analyses showed that states with greater income inequality, measured by the Gini Index, had significantly higher proportions of late diagnosis, such as Roraima and Acre. Conversely, FUs with higher HDI demonstrated better outcomes, including higher testing coverage, as observed in São Paulo.

The univariate analyses showed statistical significance for all variables except the Gini Index. HDI, aging rate, and the proportion of distributed rapid tests were inversely associated with the proportion of late HIV diagnosis among individuals aged 50 years or older when examined individually. In contrast, the SVI and illiteracy rate showed direct associations. In the negative binomial regression model adjusted for all variables, HDI changed direction and lost statistical significance when assessed jointly with the other predictors. Illiteracy rate, aging rate, and the proportion of rapid test distribution remained statistically significant and were included in the final model.

Table 3 presents the parameters of the final multivariable model, estimated using negative binomial regression, and composed of the illiteracy rate, aging rate, and the proportion of distributed rapid HIV tests.

The illiteracy rate, which showed a consistent and significant effect in both the univariate and multivariable analyses, exhibited a direct association when examined alongside the other factors. It was the contextual variable most strongly associated with late HIV diagnosis, indicating that for every one-percentage-point increase in the illiteracy rate, there is an estimated 0.8% increase in the incidence of late HIV diagnoses among individuals aged 50 years or older. Thus, at the population level, a federative unit with an illiteracy rate of 10% would be expected to have an approximately 8% higher incidence of late diagnosis in this age group, highlighting the direct impact of low educational attainment on timely access to diagnosis.

The aging rate showed an inverse association with the outcome, suggesting that states with older populations exhibit lower incidence of late diagnoses. For every one-percentage-point increase in the

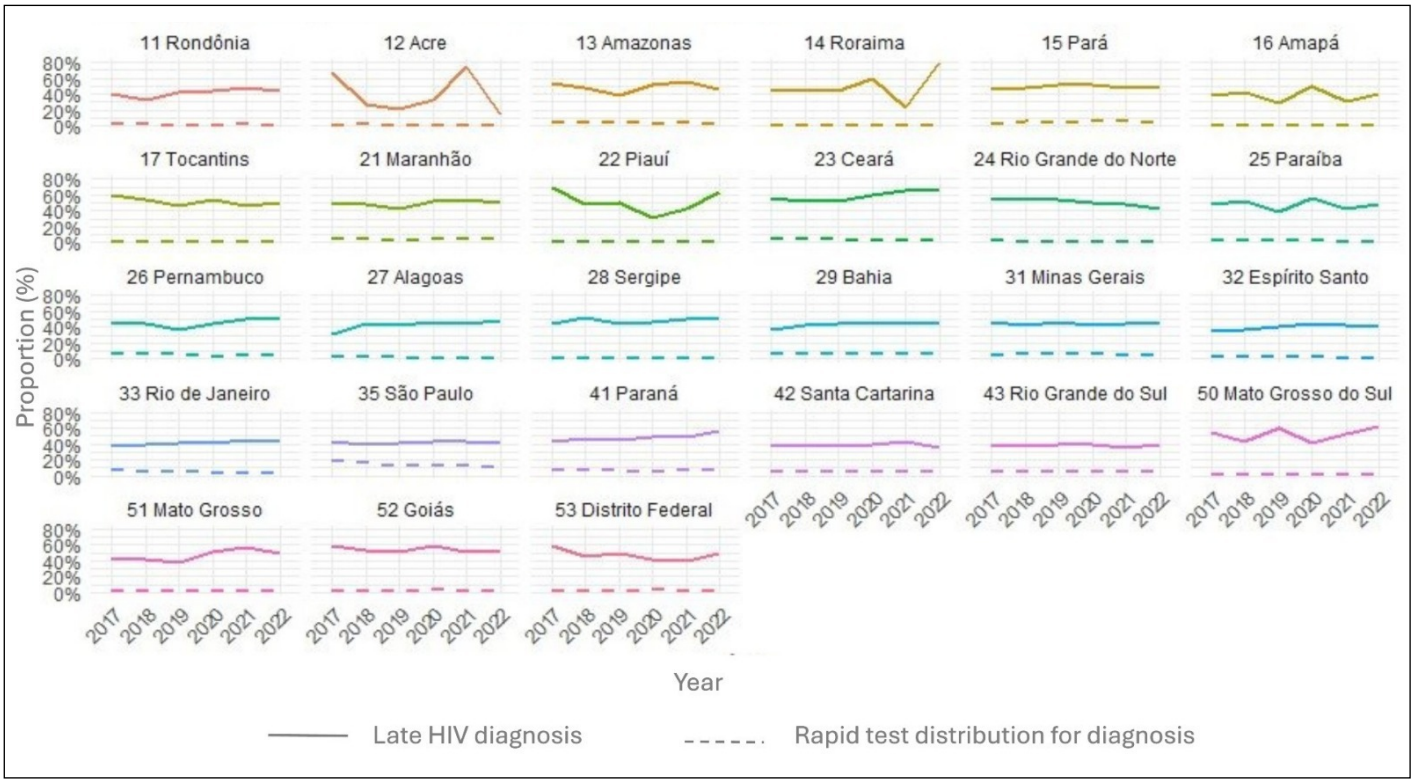

Figure 1. Proportion of late HIV diagnosis and proportion of rapid test distribution for diagnosis, by federative unit and year in Brazil (2017–2022).

Table 3. Final negative binomial multiple regression model for the proportion of late HIV diagnosis among individuals aged 50 years and older in Brazil (2017–2022).

	Rate ratio	Coefficient β	Confidence interval (CI95%)
Illiteracy rate	1.008	0.008	0.003; 0.012
Aging rate	0.985	-0.015	-0.035; -0.026
Proportion of rapid HIV test distribution	0.995	-0.005	-0.010; -0.001

aging rate, there is an estimated reduction of approximately 1.5% in the incidence of late diagnoses. At the population level, a state with an aging rate 10 percentage points higher than another may show an incidence of late diagnosis roughly 15% lower. This finding reflects contexts with greater urbanization, better living conditions, and more robust health-care infrastructure, which facilitate early detection.

The proportion of distributed rapid HIV tests demonstrated an inverse and statistically significant association with the incidence of late diagnosis. This indicates that for every one-percentage-point increase in the distribution coverage of rapid tests, there is an estimated 0.5% reduction in the incidence of late diagnoses. Considering real differences across states, a coverage level 10 percentage points higher could represent an accumulated reduction of approximately 5% in the incidence of late diagnosis, reinforcing the importance of expanding access to rapid testing as a key strategy for addressing the epidemic.

Given the prevalence of illiteracy in more vulnerable Brazilian regions and the scale of the affected population, this effect translates into a substantial number of individuals impacted, underscoring the relevance of educational and health-care access policies, particularly for more vulnerable groups. The aging rate, with its inverse association, demonstrated a protective effect, indicating that regions of the country with older populations—often associated with more favorable socioeconomic indicators—exhibit an increased capacity for early diagnosis, with the potential to reduce complications associated with late presentation to health services.

Additionally, the proportion of rapid test distribution showed a particularly notable inverse effect on late diagnosis, demonstrating the effectiveness of policies that ensure broad access to diagnostic testing and highlighting the crucial role of testing campaigns in strengthening early detection. The cumulative impact of these policies, especially in areas with high HIV incidence, emerges as a key factor in preventing complications and improving patient survival. The analyses by state reveal that states in the Northern and Northeastern regions of Brazil displayed the worst indicators related to contextual factors associated with less favorable conditions for access to health care.

Residual analysis (Figure 2) indicates a good fit for the negative binomial model (a), in which the deviance residuals remained within the envelope limits. This supports the choice of this model, in contrast to the Poisson model (b), where the residuals were systematically outside the limits, indicating excessive variability in the data. The selected model was considered appropriate based on goodness--of-fit criteria, statistical significance, and theoretical relevance, all of which corroborated the results.

The findings highlight the relevance of contextual factors as population-level determinants of late HIV diagnosis. The magnitude of the estimated coefficients indicates that interventions related to basic education, testing coverage, and population structure may have a substantial impact on reducing morbidity and mortality associated with HIV infection among older adults in Brazil.

DISCUSSION

The results of this study demonstrated that contextual factors related to socioeconomic development, social vulnerability, and health-care access policies play an important role in shaping late HIV diagnosis among individuals aged 50 years and older. The illiteracy rate emerged as a risk factor, contributing to an increase in the proportion of late diagnoses. This finding highlights the importance of education for access to information and health services, underscoring the need for educational policies and initiatives that promote HIV awareness[5]. Low educational attainment may limit access to information on prevention, symptoms, and treatment of HIV, and may also hinder understanding of the importance of early diagnosis[3]. Conversely, the aging rate and the distribution of rapid HIV tests acted as protective factors. An increase in the aging rate was associated with a reduction in late diagnosis, possibly explained by better income and development indicators in states with older populations[15]. These states tend to have more robust health-care infrastructure and better access to diagnostic services, which facilitates early detection of infection[21]. Meanwhile, increased distribution of rapid tests contributed to reducing the proportions of late diagnoses, reflecting the positive impact of policies that expand access to testing and diagnosis[1]. These results reinforce the importance of investing in strategies that broaden testing coverage, especially in regions with lower socioeconomic indicators[22].

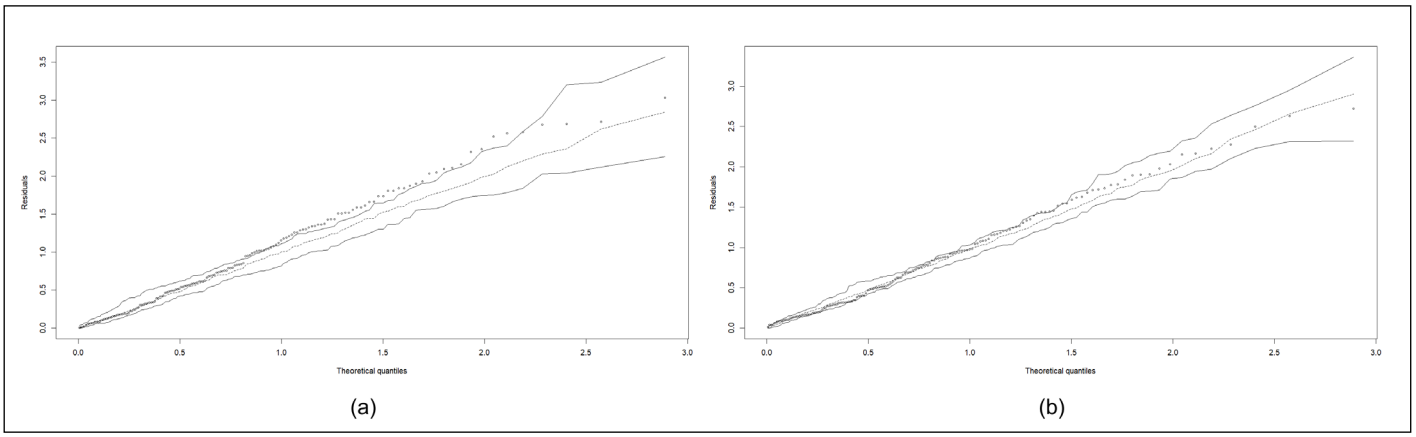

Figure 2. Residual analysis of (a) Poisson and (b) negative binomial models for the proportion of late HIV diagnosis among individuals aged 50 years and older in Brazil (2017–2022).

The analyses also revealed regional disparities, with the worst indicators observed in the North and Northeast of Brazil. These regions have less favorable conditions for accessing health care, greater social vulnerability, and lower testing coverage, which contribute to higher rates of late diagnosis[15]. States such as Piauí and Acre stood out with high proportions of late diagnosis, while São Paulo, with its higher HDI and broader testing coverage, presented better outcomes[14]. These disparities may be explained by differences in financial resources, health-care infrastructure, and public policies across regions[17]. Another relevant factor is the stigma associated with HIV, which may be more pronounced among older populations, thus hindering the pursuit of diagnosis and treatment[23]. Fear of discrimination and lack of knowledge about HIV infection can reduce health-seeking behavior, particularly in regions with limited access to information and education[24]. Additionally, the lack of evident symptoms in the early stages of infection may lead to a false sense of security, delaying diagnosis[5].

As a limitation, it is important to note that composite indices such as the SVI, Gini Index, and HDI may present effects that can be better understood when their individual components are analyzed separately. On the other hand, rate- and proportion-based indicators clearly highlighted population-level risk and protective effects. Thus, analyses should consider these perspectives to better detail the impact of contextual factors on late HIV diagnosis.

Furthermore, residual analysis confirmed the adequacy of the negative binomial model, which was selected due to data overdispersion[18]. This model allowed for a more precise assessment of the associations between contextual variables and late diagnosis, emphasizing the importance of accounting for variability in ecological studies[25].

This study identified that contextual factors—including socioeconomic development, social vulnerability, and health policies—significantly influence timely HIV diagnosis among individuals aged 50 years and older. The North and Northeast regions exhibited less favorable conditions, highlighting the need for targeted actions to reduce regional inequalities and improve access to health services. Expanding the distribution of rapid tests and combating illiteracy are essential strategies to reduce late diagnosis and improve clinical outcomes in this population.

Public policies that promote education, HIV awareness, and access to testing are crucial to addressing regional disparities and ensuring early diagnosis, ultimately contributing to better quality of life for people living with HIV in Brazil. Moreover, it is essential that health managers consider regional specificities when planning and implementing health policies, particularly in areas with greater socioeconomic vulnerability. Efforts involving government, civil society, and non-governmental organizations can broaden the reach of prevention and diagnostic initiatives, ensuring that all people—regardless of age or geographic location—have equitable and timely access to health-care services.

Strenghts

This study's main strength was the use of national data encompassing all federative units in the country, which enabled a broad and representative analysis of the Brazilian context. In addition, the application of robust statistical modeling allowed for appropriate handling of data overdispersion, yielding more precise estimates. Another strength was the population-level approach, which highlighted the implications of social and contextual determinants for the occurrence of late HIV diagnosis among individuals aged 50 years and older, providing important evidence to inform public health policies.

Limitations

It is important to acknowledge several limitations of this study. Ecological-level data do not allow for individual-level inferences, restricting interpretation to the population level; however, this does not compromise the findings, as the study objectives pertain specifically to contextual aspects across regions of the country. The use of composite indices such as HDI, SVI, and the Gini Index may limit the ability to analyze the specific effects of their components, and in this study, these indices did not reach statistical significance; for more detailed analyses, study designs and statistical approaches that consider the internal composition of these indices are recommended.

Additionally, the possibility of underreporting and heterogeneity in data quality across states may introduce bias into the results. Nevertheless, it is noteworthy that the data are drawn from a widely used national database for epidemiological analyses. Despite these limitations, the findings provide meaningful contributions to understanding the factors associated with late HIV diagnosis among older adults in Brazil.

CONCLUSION

In this study, contextual factors associated with late HIV diagnosis among individuals aged 50 years and older in Brazil between 2017 and 2022 were identified. Higher illiteracy rates significantly increased the occurrence of late diagnoses, whereas greater population aging and wider distribution of rapid HIV tests acted as protective factors.

These results fulfilled the objective of examining social determinants and health-care access indicators related to late diagnosis and reinforced the need for public policies focused on education, expansion of testing, and reduction of regional inequalities. Implementing such strategies may facilitate early diagnosis, reduce clinical complications, and promote better quality of life for older adults living with HIV in Brazil.

Approval by the Human Research Ethics Committee

Not applicable.

Author's contributions

DES: Project administration, Formal analysis, Conceptualization, Data curation, Writing – original draft, Writing – review and editing, Investigation, Methodology, Software, Supervision, Validation, Visualization. LFA: Formal analysis, Data curation, Writing – original draft, Writing – review and editing, Investigation, Methodology, Software. CBS: Writing – original draft, Writing – review and editing. FLSF: Writing – original draft, Writing – review and editing.

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Conflict of interest

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