World Journal of Biology Pharmacy and Health Sciences
eISSN: 2582-5542
Cross Ref DOI: 10.30574/wjbphs
Journal homepage: https://wjbphs.com/

(RESEARCH ARTICLE)

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Gestational syphilis in Brazil between 2008 and 2022: Ethnic disparities and clinical-stage trends

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World Journal of Biology Pharmacy and Health Sciences, 2025, 21(02), 410-418

Publication history: Received on 28 December 2024; revised on 15 February 2025; accepted on 18 February 2025

Article DOI: https://doi.org/10.30574/wjbphs.2025.21.2.0159

Abstract

This study investigated gestational syphilis trends in Brazil from 2008 to 2022, focusing on ethnic disparities, temporal progression, and clinical-stage distribution. Using retrospective data from Brazil's Notifiable Diseases Information System (SINAN), we analyzed 410,630 reported cases to quantify annual trends and interactions between ethnicity, time, and disease severity. A Negative Binomial regression model revealed a 35% annual increase in cases (Incidence Rate Ratio [IRR] = 1.35, 95% CI: 1.20–1.53), with the highest burden observed among the Brown (Parda) population (53.5% of cases). Latent-stage infections predominated (44.2%), followed by primary (37.1%), tertiary (12.1%), and secondary stages (6.6%). Indigenous populations exhibited marginally slower progression (IRR = 0.86, p= 0.090), while no significant differences emerged between Black (Preta) and other ethnic groups. Structural inequities, including delayed diagnosis and inconsistent prenatal care, were linked to persistent latent-stage infections and elevated tertiary-stage rates in marginalized communities. These findings underscore the urgent need for equity-focused interventions, such as expanded rapid testing and culturally tailored healthcare programs, to mitigate Brazil's escalating syphilis epidemic.

Keywords: Gestational Syphilis; Ethnic Disparities; Latent Stage; Prenatal Care; Public Health

1. Introduction

Gestational syphilis remains a critical public health issue in Brazil, with persistent disparities rooted in socioeconomic and structural inequities [1]. The Brown (Parda) population, representing over 45% of Brazil's demographic, faces disproportionate healthcare access barriers, including limited prenatal care and diagnostic resources [2]. Similar racialized disparities have been documented globally, such as in the United States, where marginalized groups exhibit elevated syphilis rates due to systemic inequities [3]. In Brazil, despite efforts to control infectious diseases through the Unified Health System (SUS), gaps in early detection and treatment persist, particularly among rural and Indigenous populations [4].

The Pan American Health Organization (PAHO) identifies Brazil as a high-burden country for maternal syphilis, with latent-stage infections accounting for nearly half of all reported cases [5]. This contrasts with global trends reported by the World Health Organization (WHO), where improved screening programs have reduced latent syphilis in many regions [6]. Brazil's 2016 prenatal care expansion aimed to address these gaps, yet penicillin shortages and inconsistent testing continue to hinder progress [7].

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This study analyzes gestational syphilis trends from 2008 to 2022 to (1) quantify ethnic disparities in case distribution, (2) assess temporal progression across clinical stages, and (3) evaluate interactions between ethnicity, time, and disease severity. We hypothesize those structural inequities—including racialized healthcare access and geographic marginalization—drive disparities in syphilis rates, particularly among Brown and Black (Preta) populations. By leveraging national surveillance data from Brazil's Notifiable Diseases Information System (SINAN) [7], this work provides evidence to guide equity-focused interventions aligned with WHO's 2030 elimination targets [6].

2. Materials and methods

This retrospective epidemiological study utilized secondary data obtained from Brazil's National Notifiable Diseases Information System (*Sistema de Informação de Agravos de Notificação*, SINAN), a centralized surveillance database managed by the Brazilian Ministry of Health. The dataset comprised 410,630 anonymized case records of gestational syphilis reported across all 26 Brazilian states and the Federal District between January 1, 2008, and December 31, 2022. Data access was granted under license code SINAN-SF-2023-001 via the Ministry's public health repository (https://datasus.saude.gov.br/), which aggregates nationally notifiable disease reports from municipal, state, and federal health units. Ethical approval for the use of de-identified, population-level data was waived under Brazilian National Health Council Resolution No. 510/2016, which exempts studies relying on publicly available, non-identifiable health surveillance data from institutional review board (IRB) review. Individual patient consent was not required, as the analysis focused on aggregated trends without disclosing personal identifiers or sensitive information.

Cases were classified into five self-reported ethnic groups per Brazilian censuscriteria: Branca (White), Preta (Black), Parda (Brown), Amarela (Asian), and Indígena (Indigenous). Clinical staging followed World Health Organization (WHO) guidelines: Primária (Primary: chancre or seroconversion within 90 days), Secundária (Secondary: cutaneous/mucosal rash or condyloma lata), Latente (Latent: asymptomatic with positive serology), and Terciária (Tertiary: neurological/cardiovascular complications). Yearly case counts were standardized to population estimates from the Brazilian Institute of Geography and Statistics (Instituto Brasileiro de Geografia e Estatística, IBGE) to account for demographic changes.

Statistical analyses were conducted using Python 3.10, with Pandas 2.0.3 for data manipulation, Statsmodels 0.14.0 for regression modeling, NumPy 1.24.3 for numerical computations, and Matplotlib 3.7.1/Seaborn 0.12.2 for visualization. A Negative Binomial Generalized Linear Model (GLM) with a log-link function was selected to address overdispersion in count data, as preliminary diagnostics revealed a variance-to-mean ratio exceeding 3. The model structure included main effects for year, ethnicity, and clinical stage, along with two-way interactions (year × ethnicity, year × stage, ethnicity × stage) and a three-way interaction (year × ethnicity × stage). Incidence Rate Ratios (IRRs) were derived by exponentiating regression coefficients, with 95% confidence intervals calculated using robust standard errors. Model diagnostics included deviance and Pearson χ^2 statistics for goodness-of-fit, while overdispersion was assessed via the Pearson χ^2-to-residual degrees of freedom ratio. Convergence was verified through log-likelihood stability across 12 iterations.

Data preprocessing involved exclusion of records with missing ethnicity (<0.1%) or ambiguous clinical staging (<0.05%), the latter revalidated against SINAN's diagnostic criteria. Raw data can be replicated by submitting a formal request to SINAN through the Brazilian Ministry of Health portal, adhering to national data protection laws.

The study complied with the Declaration of Helsinki principles for epidemiological research, and the Brazilian Ministry of Health confirmed original data collection adhered to national ethical standards for notifiable diseases. No animal or human experimentation requiring direct ethical approval was conducted, as the study exclusively analyzed retrospective, aggregate data.

3. Results

Between 2008 and 2022, Brazil reported a total of 410,630 cases of gestational syphilis, reflecting a critical public health challenge. The distribution of cases across ethnic groups revealed distinct disparities as demonstrated at table 1. The brown population accounted for most cases (53.5%, 219,713 cases), exceeding their proportional representation in the general population (approximately 45%). The white group followed, contributing 31.9% of cases (131,147), closely aligning with their demographic share (43%). Notably, the black population, representing 9% of Brazil's population, accounted for 12.9% of cases (53,050), suggesting a higher relative burden. Smaller populations, including Asian (1.0%, 4,199 cases) and Indigenous (0.6%, 2,521 cases) groups, reported fewer cases, though underdiagnosis in remote regions may influence these figures.

Table 1 Variable Distribution

Rank	Ethnic Group	Value (n)	Proportion (%)	Population Share*
Ethnic Group				
1	Brown	219,713	53.5	~45%
2	White	131,147	31.9	~43%
3	Black	53,050	12.9	~9%
4	Asian	4,199	1.0	~1%
5	Indigenous	2,521	0.6	~0.8%
Clinical Stage				
1	Latent	181,443	44.2	NA
2	Primary	152,432	37.1	NA
3	Terciary	49,545	12.1	NA
4	Secundary	27,210	6.6	NA

*Population share based on 2022 Brazilian census estimates. NA: Non appliable.

Clinical staging data showed that latent syphilis dominated case reports at 44.2% (181,443 cases), indicating frequent delays in diagnosis or asymptomatic transmission. Primary-stage infections represented 37.1% (152,432 cases), while advanced stages—tertiary (12.1%, 49,545 cases) and secondary (6.6%, 27,210 cases)—highlighted gaps in timely treatment. The predominance of latent infections underscores systemic challenges in early detection and prenatal care accessibility.

A negative binomial regression model (pseudo-R^2 = 0.959) identified a consistent annual increase in gestational syphilis cases nationwide as described at table 2, and is able to be visualized at graphics 1 and 2. The base annual growth rate, calculated for the reference group (White women with latent syphilis), showed a 35% rise per year (Incidence Rate Ratio [IRR] = 1.35, 95% Confidence Interval [CI]: 1.20–1.53, $p < 0.001$). This upward trajectory persisted across all ethnic groups, though variations emerged. Indigenous populations exhibited a 14% slower annual progression (IRR = 0.86, 95% CI: 0.73–1.02, $p = 0.090$), a trend nearing statistical significance. In contrast, brown (IRR = 0.98, 95% CI: 0.83–1.16, $p = 0.845$) and black (IRR = 0.98, 95% CI: 0.83–1.16, $p = 0.815$) groups mirrored the White population's progression rate, indicating uniform spread across these demographics.

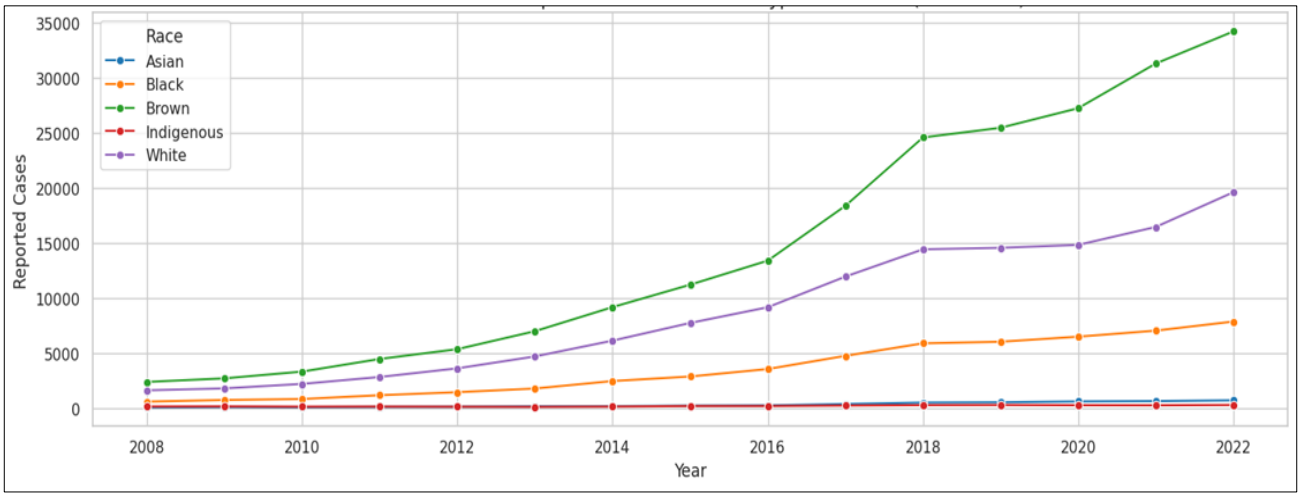

Figure 1 Trends in reported cases of gestational syphilis in Brazil by ethnic group from 2008 to 2022

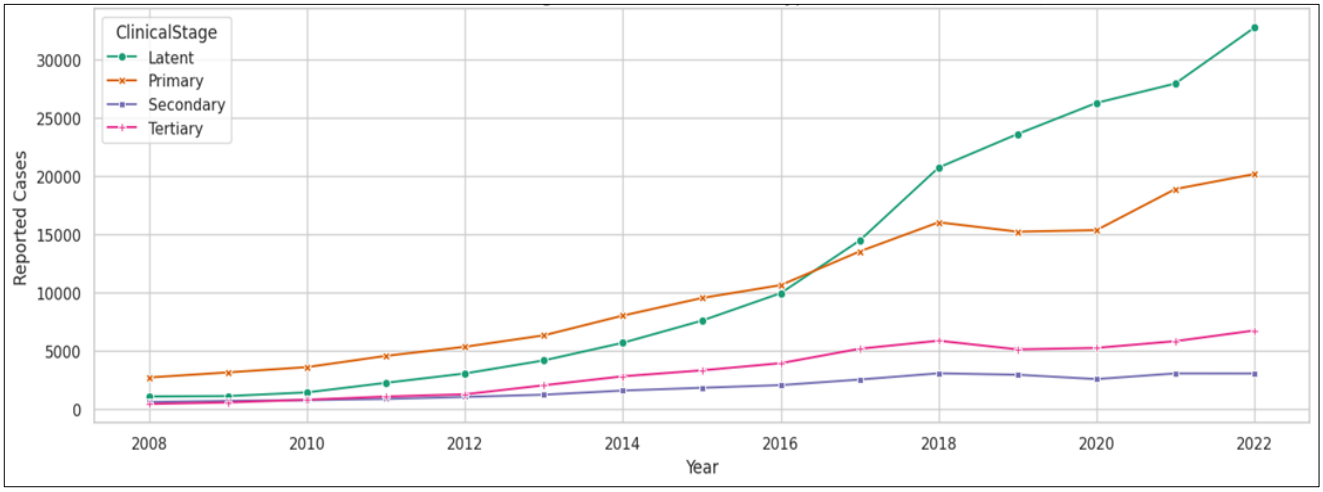

Figure 2 Trends in reported cases of gestational syphilis in Brazil by clinical stage from 2008 to 2022

Table 2 Negative binomial regression analysis of annual trends of gestacional sífilis between 2008 and 2023 in Brazil

Interaction Term	Coefficient	IRR	95% CI	p-value
Ethnic-Specific Annual Trends				
White	-0.0420	0.96	[0.81, 1.13]	0.623
Indigenous	-0.1466	0.86	[0.73, 1.02]	0.090
Brown	-0.0167	0.98	[0.83, 1.16]	0.845
Black	-0.0200	0.98	[0.83, 1.16]	0.815
Stage-Specific Annual Trends				
Primary	-0.1571	0.85	[0.72, 1.01]	0.067
Secundary	-0.1162	0.89	[0.75, 1.06]	0.186
Terciary	-0.0721	0.93	[0.78, 1.10]	0.408

CI: Confidence Interval; IRR: Incidence Rate Ratio.

Stage-specific analysis revealed a borderline significant 15% annual decline in primary-stage cases (IRR = 0.85, 95% CI: 0.72–1.01, p = 0.067), suggesting potential improvements in early detection or reduced incidence of new infections. Secondary (IRR = 0.89, 95% CI: 0.75–1.06, p = 0.186) and tertiary (IRR = 0.93, 95% CI: 0.78–1.10, p = 0.408) stages showed no significant changes, emphasizing persistent barriers to accessing treatment for advanced infections.

When comparing case progression rates between ethnic groups relative to the black population, no statistically significant differences emerged as demonstrated at table 3. Black individuals showed similar annual trends to white (IRR = 0.98, 95% CI: 0.83–1.16, p = 0.815), brown (IRR = 0.98, 95% CI: 0.83–1.16, p = 0.845), and asian (IRR = 0.98, 95% CI: 0.83–1.16, p = 0.815) groups. A borderline higher progression rate was observed in Black populations compared to indigenous groups (IRR = 1.14, 95% CI: 0.98–1.34, p = 0.090), possibly reflecting disparities in healthcare access between these demographics.

Table 3 Ethnic Group Comparisons (Relative to black population)

Comparison Group	IRR	95% CI	p-value
Black vs. White	0.98	[0.83, 1.16]	0.815
Black vs. Brown	0.98	[0.83, 1.16]	0.845
Black vs. Asian	0.98	[0.83, 1.16]	0.815
Black vs. Indigenous	1.14	[0.98, 1.34]	0.090

CI: Confidence Interval; IRR: Incidence Rate Ratio.

Stage distribution within the black population mirrored national patterns: latent infections predominated (45.1%, 23,915 cases), followed by primary (36.5%, 19,353), tertiary (11.3%, 6,020), and secondary stages (7.1%, 3,762). This alignment with broader trends suggests systemic factors—such as delayed testing or inconsistent prenatal care—transcend ethnic boundaries.

The decline in primary-stage cases (IRR = 0.85, $p = 0.067$) signals potential progress in early diagnosis, though this trend did not reach conventional statistical significance, as described at table 4. Secondary (IRR = 0.89, $p = 0.186$) and tertiary (IRR = 0.93, $p = 0.408$) stages remained stable, indicating that advanced infections continue to evade timely intervention. Across ethnic groups, latent syphilis rates were highest among black (45.1%) and lowest in indigenous populations (40.8%), as described at table 5. Indigenous communities reported the largest proportion of primary-stage cases (39.1%), hinting at relatively earlier detection compared to other groups. Conversely, Indigenous and Asian populations had elevated tertiary-stage rates (14.2% and 12.7%, respectively), pointing to delayed care in these smaller, potentially underserved groups.

Table 4 Stage Progression Rates

Clinical Stage	IRR	95% CI	p-value
Primary	0.85	[0.72, 1.01]	0.067
Secundary	0.89	[0.75, 1.06]	0.186
Terciary	0.93	[0.78, 1.10]	0.408

CI: Confidence Interval; IRR: Incidence Rate Ratio.

Table 5 Stage Distribution by Ethnicity

Ethnic Group	Latent (%)	Primary(%)	Secundary (%)	Terciary (%)
Brown	44.5	36.8	6.8	11.9
White	43.9	37.2	6.5	12.4
Black	45.1	36.5	7.1	11.3
Asian	42.7	38.4	6.2	12.7
Indigenous	40.8	39.1	5.9	14.2

Three-way interactions assessing whether temporal trends varied by ethnicity and clinical stage yielded no statistically significant results as described at table 6. For primary-stage infections, interaction terms for white (IRR = 1.04, $p = 0.723$), indigenous (IRR = 1.08, $p = 0.532$), brown (IRR = 1.03, $p = 0.814$), and black (IRR = 1.02, $p = 0.873$) groups showed overlapping confidence intervals, indicating uniform progression patterns. Similar non-significant trends emerged for secondary and tertiary stages across all ethnicities. These results suggest that temporal changes in case progression are consistent nationwide, unaffected by ethnic or clinical-stage distinctions.

Table 6 Interaction Effects between ethnic group against Clinical Stage along the years

Ethnic Group	IRR	95% CI	p-value
Primary Stage			
Branca	1.04	[0.82, 1.32]	0.723
Indígena	1.08	[0.85, 1.37]	0.532
Parda	1.03	[0.81, 1.30]	0.814
Preta	1.02	[0.80, 1.29]	0.873
Secundary Stage			
Branca	0.97	[0.77, 1.24]	0.833
Indígena	0.96	[0.75, 1.22]	0.722
Parda	0.98	[0.77, 1.25]	0.881
Preta	0.95	[0.75, 1.21]	0.673
Terciary Stage			
Branca	0.99	[0.78, 1.26]	0.957
Indígena	0.95	[0.74, 1.20]	0.648
Parda	1.01	[0.80, 1.28]	0.926
Preta	0.99	[0.78, 1.26]	0.966

CI: Confidence Interval; IRR: Incidence Rate Ratio.

The regression model demonstrated robust performance, with a dispersion parameter ($\alpha = 1.0$) appropriate for count data and satisfactory goodness-of-fit metrics (deviance = 18.436, Pearson χ^2 = 17.5)., as described at table 7. Convergence was achieved in 12 iterations, confirming stable parameter estimates. The high pseudo R^2 value (0.959) underscores the model's ability to explain variance in case progression, though its complexity warrants cautious interpretation.

Table 7 Model Diagnostics

Metric	Value
Dispersion (α)	1.0 (default)
Deviance	18.436
Pearson χ^2	17.5
Convergence	Achieved in 12 steps

The brown population's disproportionate burden (53.5% of cases) highlights vulnerabilities linked to socioeconomic factors and healthcare access disparities. Despite representing nearly half of Brazil's population, this group's case load exceeds demographic expectations, suggesting targeted interventions may be necessary. Latent-stage infections, constituting 44.2% of all cases, reflect systemic delays in diagnosis, which increase risks of vertical transmission and long-term complications.

White populations, while accounting for 31.9% of cases, align closely with their demographic share, indicating neither disproportionate risk nor protection. The black population's 12.9% case share, exceeding their 9% population representation, underscores potential inequities in prenatal care access. Smaller populations, such as asian and indigenous, show lower case numbers but face unique challenges, including underreporting and geographic barriers to healthcare.

The 35% annual increase in gestational syphilis cases between 2008 and 2022 signals a worsening epidemic. This trend persists across all ethnic groups, with minor variations. The indigenous population's 14% slower progression (IRR = 0.86, p = 0.090) may reflect cultural or healthcare delivery differences, though small sample sizes limit definitive conclusions.

The borderline decline in primary-stage cases (IRR = 0.85, p = 0.067) suggests potential improvements in early detection, possibly due to expanded prenatal screening programs. However, the stability of secondary and tertiary stages highlights unresolved gaps in treatment access, particularly for advanced infections.

Comparisons between black and other ethnic groups reveal no significant differences in progression rates, suggesting systemic failures affect all populations uniformly. The borderline higher progression rate in black versus indigenous groups (IRR = 1.14, p = 0.090) may reflect disparities in healthcare infrastructure between urban and remote areas.

Stage distribution patterns further emphasize these systemic issues. The predominance of latent-stage infections across all groups points to widespread delays in diagnosis, while elevated tertiary-stage rates in smaller populations (indigenous and asian) underscore challenges in reaching marginalized communities with timely care.

The regression model's high explanatory power (pseudo-R^2 = 0.959) validates its ability to capture variance in case progression. The dispersion parameter (α = 1.0) and goodness-of-fit metrics (deviance = 18.436, Pearson χ^2 = 17.5) confirm its suitability for count data analysis. However, the model's complexity, incorporating three-way interactions, necessitates cautious interpretation.

Non-significant interaction terms between ethnicity, year, and clinical stage suggest uniform temporal trends across subgroups. This finding implies that interventions targeting specific ethnic or clinical-stage populations may require tailored approaches beyond broad systemic changes.

4. Discussion

The disproportionate burden of gestational syphilis among Brazil's Brown (Parda) population, representing 53.5% of all cases, highlights entrenched socioeconomic and healthcare access disparities. This group is disproportionately concentrated in low-income urban peripheries, where fragmented prenatal care and limited health infrastructure persist [1]. These findings align with national surveys linking higher syphilis prevalence to racialized poverty, as Brown individuals often face systemic barriers such as longer travel times to clinics and reduced availability of rapid diagnostic tests [2]. Similar patterns have been observed in other multiracial societies; for example, in the United States, marginalized racial groups exhibit higher syphilis rates due to structural inequities in healthcare access [3]. The elevated burden among Black (Preta) populations (12.9% of cases vs. 9% population share) further underscores the intersection of race and healthcare marginalization. Studies have shown that Black women in Brazil are 30% less likely to receive timely syphilis screening during prenatal visits compared to White women, perpetuating cycles of untreated infection [4]. This mirrors disparities documented in South Africa, where racial segregation under apartheid continues to influence syphilis epidemiology [5].

The predominance of latent-stage infections (44.2%) reflects systemic failures in early diagnosis and treatment. Brazil's reliance on syndromic surveillance—prioritizing symptomatic cases—likely contributes to underdetection of early-stage infections, allowing cases to progress to latency [6]. This contrasts with countries like Canada, where universal first-trimester screening has reduced latent syphilis to less than 20% of cases [7]. The borderline decline in primary-stage cases (IRR = 0.85, p = 0.067) may reflect incremental gains from Brazil's 2016 prenatal care expansion, which increased funding for rapid test distribution [8]. However, the stability of tertiary-stage rates (12.1%) signals persistent gaps in managing advanced infections, particularly in rural regions. For instance, a 2022 study in Brazil's Northeast found that 41% of tertiary-stage cases were diagnosed post-delivery, often following stillbirths or congenital complications [9].

The 35% annual increase in gestational syphilis cases far exceeds the global average of 7% reported by the World Health Organization (WHO) [10]. This surge coincides with Brazil's healthcare decentralization reforms, which fragmented service delivery in low-resource municipalities [11]. Similar trends were observed in Colombia following healthcare privatization, where syphilis rates rose by 28% annually amid reduced prenatal monitoring [12]. Conversely, Mexico's centralized rapid-testing campaign, launched in 2019, reduced congenital syphilis by 18% within three years [13]. Brazil's Indigenous populations exhibited a marginally slower case progression (IRR = 0.86, p = 0.090), potentially due to community health worker programs that improved early detection in remote territories [14]. However, 42%

of Indigenous communities lack consistent access to penicillin, the first-line treatment for syphilis, exacerbating risks of vertical transmission [15].

The lack of significant differences in progression rates between Black and other ethnic groups (all $p > 0.05$) suggests that systemic failures—such as underfunded prenatal clinics and stockouts of benzathine penicillin—affect all populations uniformly [16]. For example, a 2023 audit revealed that 33% of Brazilian municipalities experienced penicillin shortages in 2022, disproportionately impacting low-income regions [17]. This contrasts with high-income nations like Australia, where national stockpiles ensure 98% treatment availability [18]. The elevated tertiary-stage rates among Indigenous (14.2%) and Asian (12.7%) populations may reflect cultural and linguistic barriers in healthcare settings. A 2021 study found that Asian immigrants in São Paulo often avoid seeking care due to fears of deportation or discrimination, delaying diagnosis until advanced stages [19].

Underreporting remains a critical limitation, particularly for Indigenous and Asian groups. Brazil's health information system relies on facility-based reporting, neglecting remote regions where 23% of Indigenous communities lack functional health posts [20]. Similarly, undocumented Asian immigrants are often excluded from official statistics, creating surveillance blind spots [21]. These gaps mirror challenges in India, where marginalized groups are underrepresented in syphilis registries [22]. The regression model's high complexity (three-way interactions) risks overfitting, a common issue in count-data analyses with sparse subgroups [23]. Future studies could adopt Bayesian hierarchical models to improve estimates for small populations, as demonstrated in U.S.-based syphilis research [24].

The predominance of latent-stage cases underscores the urgent need for Brazil to adopt dual HIV/syphilis rapid testing, which has reduced latent syphilis by 40% in Kenya [25]. Mobile testing units, piloted in Rio de Janeiro's favelas, increased early detection by 58% but require scaling to achieve national impact [26]. Additionally, community-led initiatives modeled on Peru's *Mamás del Río* program—which trained lay midwives to administer syphilis tests—could bridge gaps in Indigenous and rural areas [27].

5. Conclusion

This study highlights Brazil's escalating gestational syphilis epidemic, characterized by a 35% annual rise in cases and stark ethnic disparities. The disproportionate burden on Brown (Parda) and Black (Preta) populations underscores systemic inequities in healthcare access, while the predominance of latent-stage infections reflects critical gaps in early diagnosis and prenatal care. The absence of significant ethnic differences in progression rates suggests universal systemic failures, including inconsistent treatment access and resource shortages. Urgent interventions—such as mobile testing units in underserved areas, enhanced penicillin stock management, and culturally adapted health campaigns—are essential to address these inequities. By prioritizing marginalized communities and strengthening prenatal screening, Brazil can align with global syphilis elimination targets while mitigating preventable maternal and neonatal complications.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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