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Temporal trend and spatial distribution of Chagas disease in the Northern Region of Brazil: an alert for the state of Pará

Tendência temporal e distribuição espacial da Doença de Chagas na Região Norte do Brasil: um alerta para o estado do Pará

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Karen Nickole Sousa Neves¹

<https://orcid.org/0000-0002-4533-0586?lang=pt>

<https://lattes.cnpq.br/8486097349630304>

Afya Faculdade de Ciências Médicas de Bragança, PA, Brasil

E-mail: nickolenevesmed@gmail.com

Julianne Beathriz Abdon do Rosário²

<https://orcid.org/0000-0003-2744-0498>

<http://lattes.cnpq.br/6078276532454786>

Afya Faculdade de Ciências Médicas de Bragança, PA, Brasil

E-mail: jbeathrizabdon@gmail.com

Bruna Lima Abdon³

<https://orcid.org/0000-0001-7096-7231>

<http://lattes.cnpq.br/4301830227738837>

Afya Faculdade de Ciências Médicas de Bragança, PA, Brasil

E-mail: brunaabdon.ba@gmail.com

Aurycéia Jaquelyne Guimarães-Costa⁴

<https://orcid.org/0000-0001-7249-604X>

<http://lattes.cnpq.br/5342395629825218>

Afya Faculdade de Ciências Médicas de Bragança, PA, Brasil

E-mail: auryceia@gmail.com



Abstract

This study analyzed the temporal trend and spatial distribution of Chagas disease (CD) cases in the Northern Region of Brazil between 2013 and 2023, using data from the Notifiable Diseases Information System (SINAN/DATASUS). Confirmed cases of acute CD reported in the seven states of the region were included, and variables such as state of residence, sex, age group, and municipality were examined. The results revealed marked regional heterogeneity. Pará accounted for 79% of all notifications, totaling 2,688 cases, with notable concentrations in municipalities such as Abaetetuba, Breves, Belém, Cametá, and Curralinho, which represented true transmission hotspots. A significant increase in notifications was also observed after 2020, following

¹ Medical student at Afya Faculty of Medical Sciences in Bragança, Bragança, Pará, Brazil.

² Graduated in Law from the University Center of the State of Pará - CESUPA. Medical student at Afya Faculty of Medical Sciences in Bragança, Bragança, Pará, Brazil.

³ Graduated in Pharmacy from the University Center of the State of Pará - CESUPA. Medical student at Afya Faculty of Medical Sciences in Bragança, Bragança, Pará, Brazil.

⁴ PhD in Environmental Biology from the Federal University of Pará (UFPA). Professor at the Faculty of Medical Sciences of Bragança.

a decline coinciding with the critical period of the COVID-19 pandemic. Age-group analysis showed greater involvement among adults aged 20 to 59 years, a group associated with the processing and consumption of regional foods such as açaí, the main product implicated in oral transmission in the Amazon. The distribution between sexes was balanced, suggesting a community-level exposure pattern. In the other states, low-notification profiles were observed, with small clusters in Amazonas, Amapá, Acre, and Tocantins, while Rondônia and Roraima reported minimal numbers, possibly influenced by underreporting and structural limitations in surveillance. The findings reinforce that CD remains a major public health challenge in the Northern Region, particularly in Pará, where productive, socioenvironmental, and structural factors combine to sustain the circulation of *Trypanosoma cruzi*. The results highlight the need for continuous surveillance, strengthening of Primary Health Care, improvement of sanitary practices in açaí processing, and expansion of diagnostic capacity to reduce transmission and enhance early disease detection.

Keywords: *Trypanosoma cruzi*. Neglected tropical diseases. Oral transmission. Contaminated açaí.

Resumo

*Este estudo analisou a tendência temporal e a distribuição espacial dos casos de DC na Região Norte entre 2013 e 2023, utilizando dados do Sistema de Informação de Agravos de Notificação (SINAN/DATASUS). Foram incluídos casos confirmados de DC aguda registrados nos sete estados da região, analisando-se variáveis como unidade federativa, sexo, faixa etária e município de residência. Os resultados evidenciaram uma marcada heterogeneidade regional. O Pará concentrou 79% de todas as notificações, totalizando 2.688 casos, com destaque para municípios como Abaetetuba, Breves, Belém, Cametá e Curralinho, que configuraram verdadeiros hotspots de transmissão. Observou-se também um aumento expressivo das notificações a partir de 2020, após uma queda coincidente com o período crítico da pandemia de COVID-19. A análise etária demonstrou maior acometimento em adultos de 20 a 59 anos, faixa associada ao processamento e consumo de alimentos regionais, como o açaí, principal produto envolvido na transmissão oral na Amazônia. A distribuição entre os sexos foi equilibrada, sugerindo um padrão de exposição comunitária. Nos demais estados, observaram-se perfis de baixa notificação, com focos pontuais no Amazonas, Amapá, Acre e Tocantins, enquanto Rondônia e Roraima apresentaram números mínimos, possivelmente influenciados por subnotificação e limitações estruturais da vigilância. Os achados reforçam que a DC permanece como um importante desafio de saúde pública na Região Norte, especialmente no Pará, onde fatores produtivos, socioambientais e estruturais se combinam para manter a circulação do *Trypanosoma cruzi*. Os resultados destacam a necessidade de vigilância contínua, fortalecimento da Atenção Primária, melhoria das práticas sanitárias no processamento do açaí e expansão da capacidade diagnóstica para reduzir a transmissão e melhorar a detecção precoce da doença.*

Palavras-chave: *Trypanosoma cruzi*. Doenças tropicais negligenciadas. Transmissão oral. Açaí contaminado

1. Introduction

American trypanosomiasis, commonly known as Chagas disease (CD), is an infecto-parasitic tropical disease directly associated with a high mortality burden, affecting thousands of people annually in the Americas, especially in Brazil (PAHO/WHO, 2023). It is one of the infectious diseases often related to poverty (Zhu *et al.*, 2024), and its etiological agent is the flagellated protozoan *Trypanosoma cruzi* (Trypanosomatidae), which can be transmitted mainly through contact with the parasite via an insect vector known as the triatomine bug. It may also be transmitted through blood transfusion, organ transplantation, during pregnancy and childbirth, and through the ingestion of contaminated food (PAHO, 2023). *Trypanosoma cruzi* presents three distinct forms during its heteroxenous life cycle: amastigote, epimastigote, and trypomastigote, which are responsible for the high prevalence of this anthroponosis in South America (ZHU *et al.*, 2024), since it is transmitted mainly by hematophagous insects popularly known as “barbeiros,” “chupões,” “procotós,” or “bicudos” (VASCONCELOS, 2013).

Chagas disease (CD) can be classified into an acute phase, which may last from 4 to 8 weeks, or it may progress to the chronic phase, lasting several years or decades (Vilhena, 2020). The acute phase presents high parasitemia and may or may not show signs such as fever, headache, weakness, malaise, loss of appetite, hepatosplenomegaly, and the characteristic Romaña sign (ALVES, 2019). If not properly managed, CD may progress to chronicity. The indeterminate chronic phase does not present evident clinical signs, relying on serological tests for diagnosis (ALMEIDA, 2021), while in the symptomatic phase, the patient exhibits characteristic signs and symptoms associated with disease complications, mainly affecting the cardiac and digestive systems, such as cardiomegaly, megacolon, and megaesophagus (CORREIA J. R. *et al.*, 2021).

According to the World Health Organization, it is estimated that more than 7 million people worldwide are infected with *T. cruzi* (WHO, 2024). Additionally, in Brazil, CD is among the four leading causes of death resulting from infectious and parasitic diseases, and it is considered an endemic disease in the Northern region, with high incidence in the states of Pará, Amazonas, Acre, and Amapá (CUNHA *et al.*, 2021). In this region, CD is frequently associated with the consumption of contaminated foods such as açaí and bacaba (vectorial and oral transmission). Although these routes have gained attention in efforts to prevent contamination, the Ministry of Health estimates that nearly 5 million people are chronically infected with *T. cruzi*, and most may be asymptomatic (DIAS *et al.*, 2015).

The Northern Region of Brazil also presents an epidemiological profile marked by a high occurrence of neglected tropical diseases, such as malaria, which accounts for approximately 98 to 99% of autochthonous cases recorded in the country (RODRIGUES *et al.*, 2021), especially in the states of Amazonas, Pará, and Acre. Leishmaniasis, both in its tegumentary and visceral forms, is also endemic in the region (Silva, 2022), in addition to arboviruses such as dengue, Zika, and chikungunya, which circulate seasonally and cause recurrent outbreaks. Particularly relevant is Oropouche fever, an arboviral disease almost restricted to the Amazon, responsible for recent outbreaks in states such as Amazonas, Rondônia, and Acre (BRAZIL, 2023).

Thus, by emphasizing the epidemiological importance and the public health challenges posed by Chagas disease, this study aims to analyze the temporal trend and spatial distribution of Chagas disease in the Northern Region of Brazil from 2013 to 2023, in order to identify patterns of occurrence and areas of greater concentration,

contributing to the demand for strategic actions with effective measures for its control and prevention.

2. Methodology

Study area

The present study was conducted in the Northern Region of Brazil, which is composed of the states of Acre, Amapá, Amazonas, Pará, Rondônia, Roraima, and Tocantins. This region, which has the largest territorial extension in the country, is characterized by wide ecological diversity, predominance of the Amazon biome, and high socioenvironmental vulnerability. According to data from the IBGE (Brazilian Institute of Geography and Statistics), its population was estimated at approximately 17.35 million inhabitants in 2022, with the state of Pará being the most populous, with around 8.12 million inhabitants, representing almost half of the population of the Northern Region. This demographic and territorial heterogeneity justifies the choice of the region as the setting for analysis, considering its history of endemics associated with oral and vector-borne transmission of Chagas disease.

Data collection

The information used was obtained from the Department of Informatics of the Unified Health System (DATASUS), specifically from the Notifiable Diseases Information System (SINAN), available at <https://datasus.saude.gov.br/>. Records of confirmed cases of acute Chagas disease reported between 2013 and 2023 were included, covering all states that make up the Northern Region. The variables considered in the data collection were federative unit, year of notification, sex, and age group of the affected individuals.

The raw data were extracted in .CSV format and subsequently subjected to a verification and cleaning process, which involved removing duplicates, excluding inconsistent or incomplete notifications, such as those lacking information on municipality of origin, sex, or age, and standardizing categories according to the model used by the Ministry of Health. The final database was structured and analyzed using Microsoft Excel (Microsoft 365) spreadsheets, performing descriptive analyses with calculations of absolute and relative frequencies, in addition to creating time series to represent the temporal evolution of the disease. For spatial analysis, cases were aggregated by municipality and state, allowing the observation of patterns of concentration and dispersion of the infection in the region. The creation of graphs and diagrams was performed using the RawGraphs platform (<https://www.rawgraphs.io/>), and the final editing of the figures was carried out in the Inkscape v1.4.2 software (<https://inkscape.org/pt-br/>). The cartographic analysis had a descriptive and exploratory character, with the objective of identifying spatial patterns and possible areas of concentration ("hotspots") of Chagas disease in the Northern Region of Brazil, especially in the state of Pará, where a higher notification burden is observed.

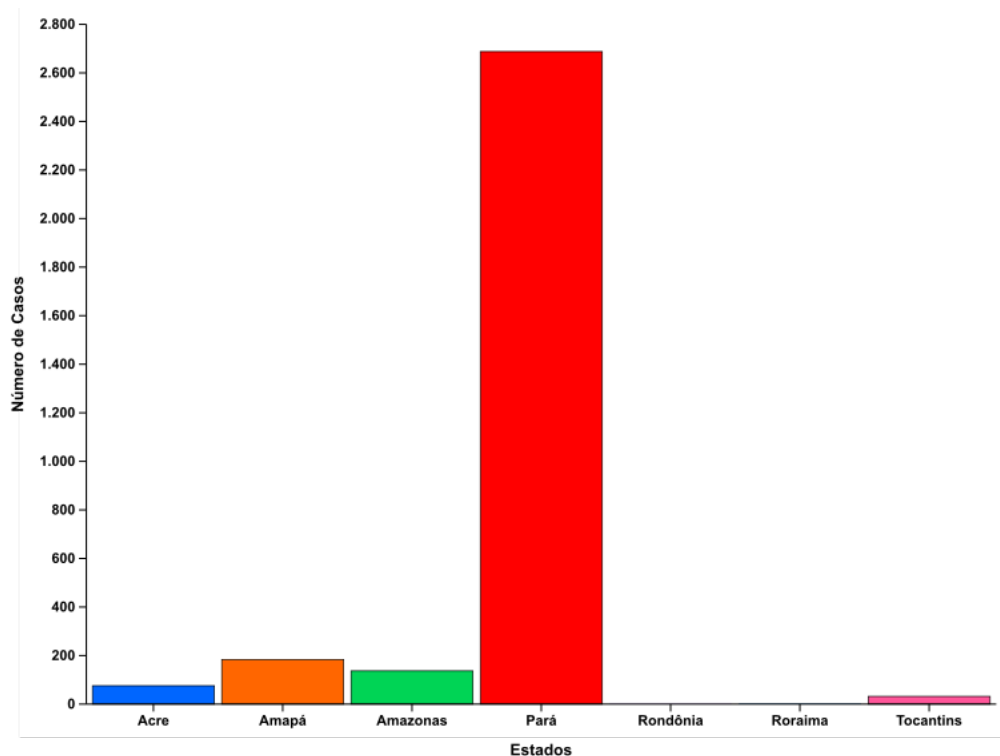
3. Results

General trend in the Northern Region

The state of Pará presents, in an unequivocally superior manner, the highest burden of reported cases throughout the entire period, standing out as the epicenter of acute or chronic Chagas disease notification in the region (Figure 1). The curve for Pará shows an upward trend in the initial years, reaching a peak between 2016 and 2017 with approximately 300 cases, followed by a slight decrease until 2020 (Figure

2). More critically, the state demonstrates a steep and exponential increase starting in 2020, culminating in 2023 with the highest peak of cases observed in the historical series, surpassing the mark of 400 cases.

Figure 1. Total number of reported Chagas disease cases in the Northern Region of Brazil between 2013 and 2023, distributed by state. A marked concentration of cases is observed in Pará, which far exceeds all other states, followed by Amapá, Amazonas, Acre, and Tocantins. Rondônia and Roraima reported only minimal numbers of notifications during the period analyzed.



Between 2013 and 2023, Pará recorded a total of 2,688 cases of CD. The municipalities of Abaetetuba (with the highest number, around 330–340 cases) and Breves (with approximately 300 cases) emerged as the two main notification hotspots for CD. Together, they represented a substantial portion of the disease burden in the state. Belém (the capital), Cametá, and Curralinho also showed an extremely high contribution, with numbers ranging from 150 to 250 cases. The predominance of these five municipalities was the key factor that elevated Pará to the position of the state with the highest number of cases in the Northern Region. They acted as disease “hotspots,” requiring prioritized surveillance and control actions. Among the municipalities with medium disease burden, Barcarena and Muaná followed the main group, with reported case numbers ranging from 100 to 120 (Figure 3).

Figure 2. Temporal trend of reported Chagas disease cases in the Northern Region of Brazil from 2013 to 2023, distributed by state. Pará shows a consistently rising trajectory across the historical series, with prominent peaks between 2016–2017 and in 2023. The other states display a pattern of low notification with occasional fluctuations, particularly in Amapá, Amazonas, Acre, and Tocantins. Rondônia and Roraima maintain minimal case numbers throughout the analyzed period.

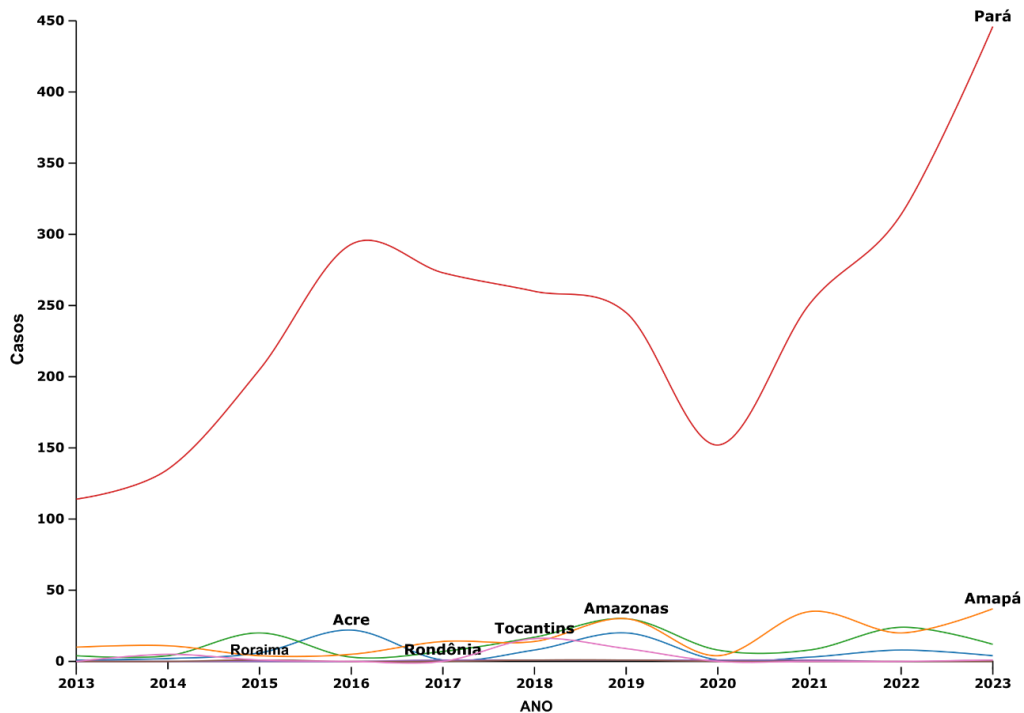
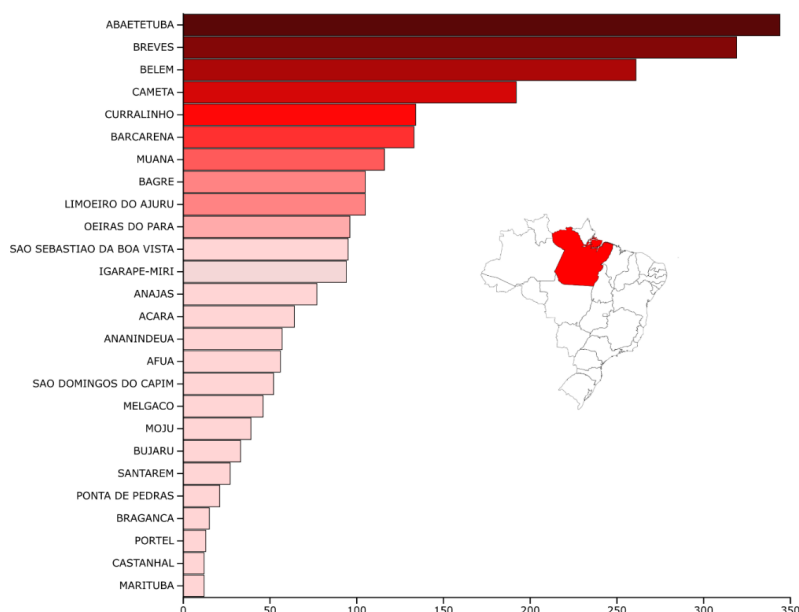
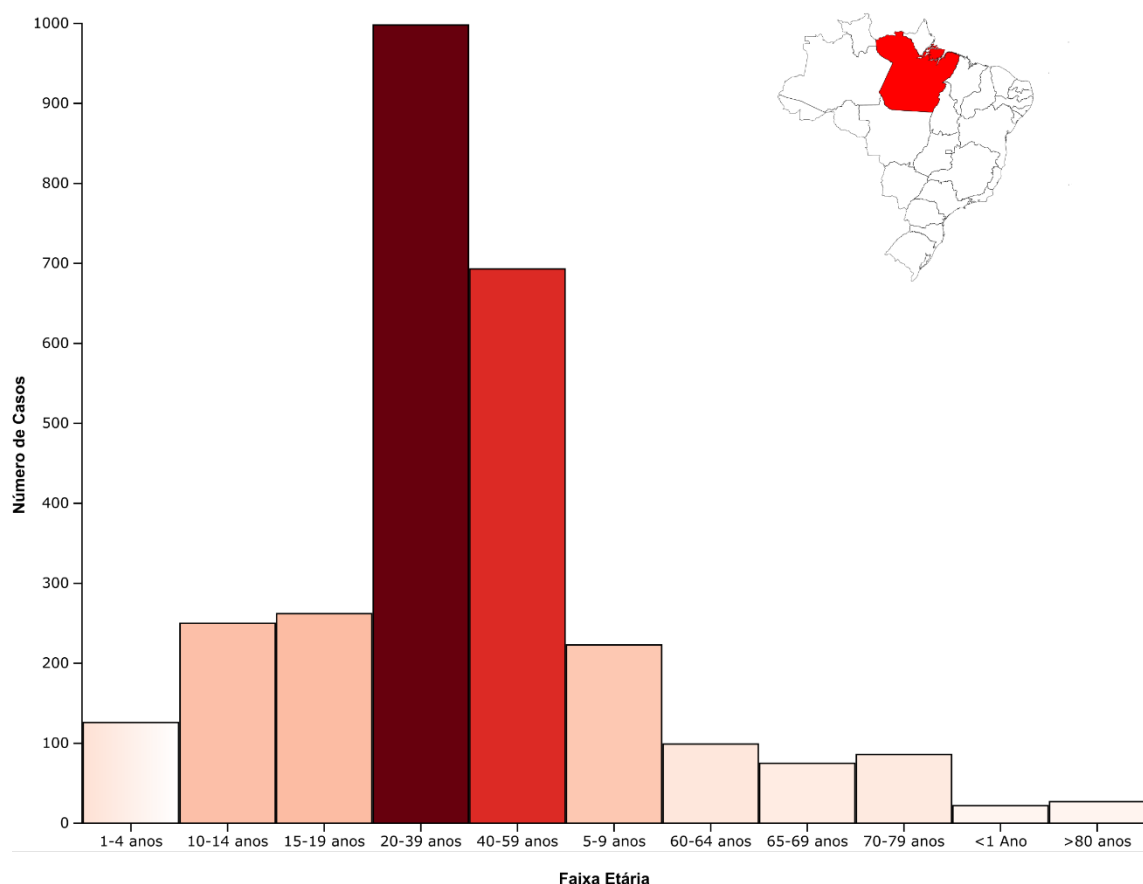


Figure 3. Distribution of reported Chagas disease cases across municipalities in the state of Pará from 2013 to 2023. A high concentration of cases is observed in Abaetetuba, Breves, Belém, Cametá, and Curralinho, which represent the main hotspots of the disease in the state. The remaining municipalities show intermediate or low case burdens, highlighting the spatial heterogeneity of transmission in the region.



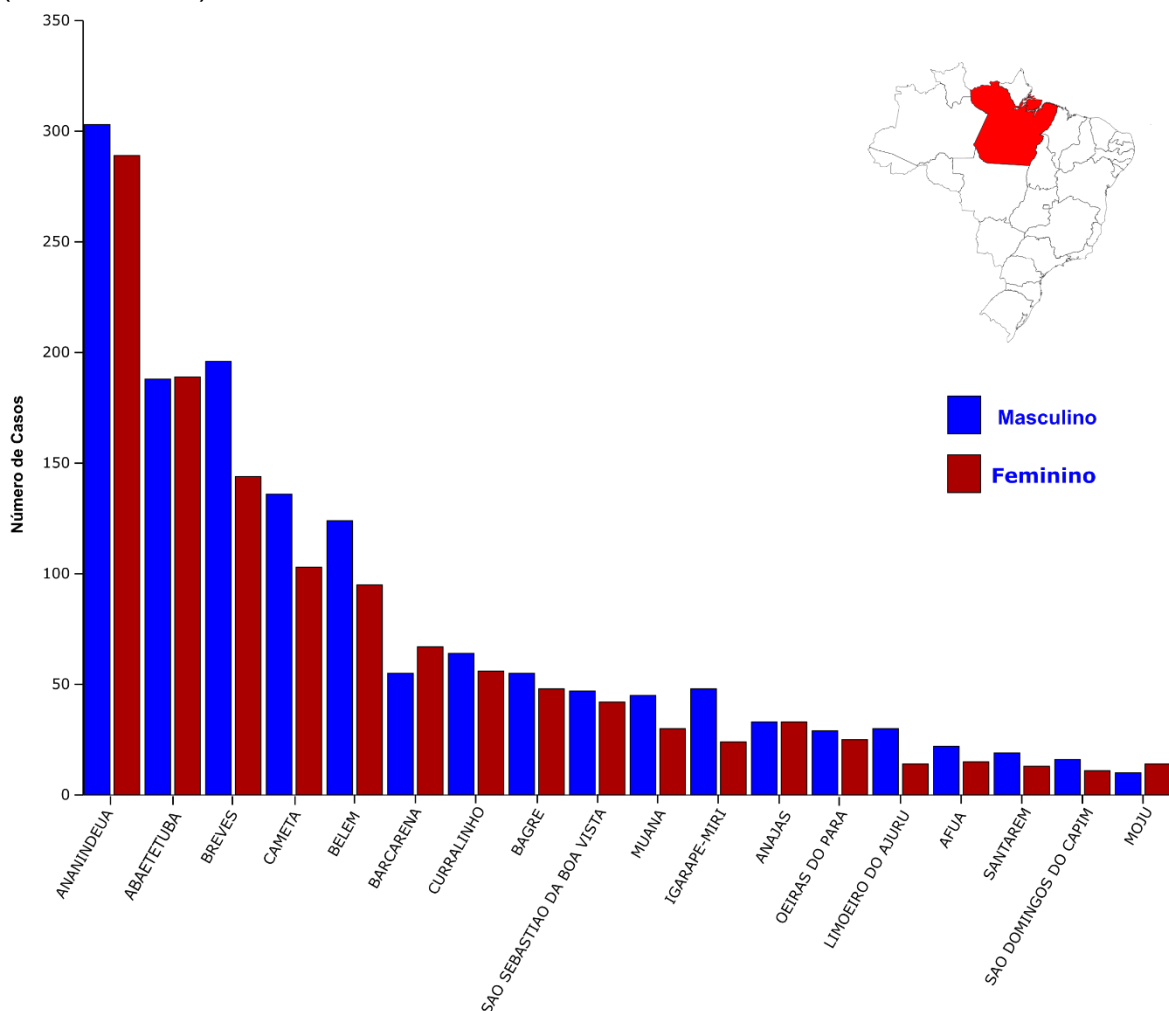
The analysis of age-group distribution showed a higher concentration in economically active age ranges, in which the 20–39-year group presented the highest number of notifications, surpassing 950 records, followed by the 40–59-year group, with approximately 700 cases. These two age groups, together, corresponded to the absolute majority of notifications in the period analyzed. To a lesser extent, cases were also identified among children and adolescents, particularly in the 10–14-year and 15–19-year groups, both with approximately 250 records. Children aged 5–9 years and 1–4 years showed reduced, yet still relevant, occurrence, suggesting active transmission among younger groups. The occurrence of notifications among elderly individuals was markedly low, with numbers below 120 cases distributed across the 60–84-year range and above 80 years, indicating that the disease burden tends to concentrate in younger and adult populations (Figure 4).

Figure 4. Distribution of reported Chagas disease cases in the state of Pará from 2013 to 2023 by age group. A pronounced concentration of cases is observed among individuals aged 20–39 and 40–59 years, representing the majority of notifications. Younger age groups, including children and adolescents, also show notable case counts, indicating active transmission. Older adults exhibit lower notification levels. The map highlights the geographic location of Pará within Brazil.



The distribution of cases between men and women in Pará (Figure 5) revealed an epidemiology of community transmission with localized tendencies, with the overall distribution of cases in the state being close to parity between the sexes, which is a finding frequently associated with oral transmission in the Amazon, as it affects both sexes indiscriminately; however, a slight predominance of notified cases in females was observed in major urban centers and metropolitan areas, such as Ananindeua and Abaetetuba, possibly due to greater health-seeking behavior and screening, or greater domestic exposure; conversely, municipalities with a strong estuarine/riverside profile, such as Breves and Cametá, show a subtle male predominance, which may be related to specific occupational exposures in rural or extractive environments with higher risk of contact with the sylvatic cycle of *T. cruzi*.

Figure 5. Distribution of the number of Chagas Disease cases between men (Masculine) and women (Feminine) in the main municipalities of the state of Pará (2013 to 2023).



Based on the epidemiological analysis in Amazonas, the disease profile in the state, although with a volume of cases significantly lower than that of Pará, presented characteristics of a low-notification endemic with concentrated hotspots. The cases were concentrated in the capital, Manaus (approximately 43 cases), functioning as the main diagnostic hub, which is frequently observed in capitals that centralize laboratory

capacity for the chronic form of the disease. However, important notification clusters exist in inland municipalities such as Barcelos, Carauari, and Amaturá, demonstrating the persistence of the sylvatic cycle and sporadic transmission in riverside and extractive areas. The age-group analysis indicated that most cases were concentrated in adult and economically active populations, with peaks in the 20–39 and 40–59-year ranges. Despite this, the occurrence of cases among children (1–4 years and 5–9 years) confirmed the existence of active transmission, probably oral or vertical, within the state.

Amapá reported 184 cases (47.28% in men and 52.71% in women) recovered during the decade studied, of which 129 were reported in the capital Macapá (70.11%), followed by 41 cases (22.28%) reported in the city of Santana, which is part of the metropolitan region of Macapá. The remaining notifications (7.61%) were divided among the municipalities of Pedra Branca do Amapari, Mazagão, Tartarugalzinho, Porto Grande, and Itaúbal. The highest incidence of notifications occurred in the 20–59-year age group, with 120 cases, corresponding to 65.21% of the total. Acre recorded a total of 77 cases of CD, showing strong evidence of ongoing transmission concentrated in inland areas rather than in the capital. The notifications were mostly concentrated in Feijó (22 cases), Marechal Thaumaturgo (17 cases), and Cruzeiro do Sul (16 cases), which together accounted for approximately 71% of the total. The age-group analysis revealed a pattern distinct and more concerning than in the other states, pointing to a higher number of cases in the 10–14-year (10 cases) and 15–19-year (9 cases) ranges, in addition to the absolute peak in the 20–39-year range (29 cases). Crucially, the age groups of under 1 year (4 cases), 1–4 years (8 cases), and 5–9 years (7 cases) totaled 19 cases.

The epidemiological profile identified in Tocantins reflects an endemic of very low notification and focalized character. The highest proportion of cases is concentrated in young and middle-aged adults, specifically in the 20–39 and 40–59-year ranges, with a slight predominance of female cases. The disease burden is heavily concentrated in Aparecida do Rio Negro, which accounts for most notifications (13 cases, representing 37.1% of the total), followed by Araguaína (8 cases) and Arixá do Tocantins (5 cases). Together, these three localities represent approximately 74% of all reported cases, indicating that CD surveillance and/or transmission in the state is limited to specific geographic hotspots, while the remaining municipalities report only 1 or 2 cases. The highest proportion of cases is concentrated in adults and older adults, specifically in the 20–39 and 40–59-year age groups.

The state of Rondônia reported only 5 cases of CD during the period from 2013 to 2023. The distribution of these cases was concentrated in three municipalities: Porto Velho, with 3 cases, representing the majority of notifications (60% of the total), followed by Ji-Paraná and Machadinho D'Oeste with 1 case each.

The epidemiological surveillance data for Roraima, with a total of only 3 to 4 cases reported in the period, indicate an extremely low and insufficient notification coverage, which, scientifically, obscures the real prevalence and incidence of Chagas disease (CD) in the state. The sparse municipal distribution, with a single case in Alto Alegre, Boa Vista, and Caracaraí, and the inclusion of a case from a municipality in another state (Turilândia, Maranhão, in the age-group and sex data), suggest a passive and unstructured surveillance system for CD. In terms of age group and sex, the count of one or two cases per category prevents any statistically valid or robust epidemiological inference about the transmission dynamics (whether chronic or acute, or whether it predominates in one sex or age).

4. Discussion

Chagas Disease and its prevalence in the Northern Region

Chagas disease is one of the main parasitic endemics in the Americas, with a global estimate of 7 million infected individuals. In the Brazilian context, the Northern Region emerges with the highest disease burden, a fact evidenced by the notification of 3,403 cases in SINAN between 2013 and 2023. Our analyses revealed that the historical series in the region showed a general pattern of increase in the number of confirmed cases over the last decade, indicating the persistence of endemicity and the potential worsening of the epidemiological situation.

When detailing the data by federative unit (Figure 1), we observed a marked heterogeneity in the distribution of reported cases. The state of Pará concentrated the vast majority of records, accounting for 79% of confirmed CD cases in the Northern Region. Conversely, the state of Roraima showed minimal prevalence, contributing only 0.09% of total notifications. This geo-regional disparity may be multifactorial, involving factors ranging from vector ecology and the specific geographic characteristics of each state to the installed capacity of regional health systems.

Primary Health Care Coverage and Structural Limitations in Surveillance

Primary Health Care (PHC), recognized as the main point of contact between the population and the health system and the level of care closest to the community, plays a strategic role in the surveillance and early diagnosis of CD. Supporting this hypothesis, the analysis of PHC coverage data (obtained through e-Gestor Atenção Básica and IBGE) demonstrated an unbalanced distribution of population density per PHC unit across the states. Our hypotheses suggest a potential overload of the primary care system in some localities, which, combined with a lack of professional training or well-defined protocols for neglected diseases such as CD, may result in underreporting of cases, explaining part of the discrepancy observed in regional prevalence rates. The data show that states such as Acre, Tocantins, and Pará present an average population per unit below 5,000 inhabitants, which represents a more favorable coverage density compared to the other states of the Northern Region. Conversely, Amapá, Roraima, and Amazonas record a number of inhabitants per unit exceeding 6,000, suggesting a greater per capita care burden.

This disparity in the average population per PHC unit constitutes a structural limitation at the primary level of care, with potential direct impact on the effectiveness of surveillance and reporting of Infectious and Parasitic Diseases (IPDs), such as Chagas disease. States with a lower average population per PHC unit tend to favor better detection and active surveillance. On the other hand, excessive population load per unit may lead to system overload, negatively affecting diagnostic and therapeutic processes, ultimately resulting in underreporting of cases that may obscure the true magnitude of CD in the region (SHAMI *et al.*, 2023).

Primary Health Care is essential in the identification and notification of CD, since in cases of suspected *T. cruzi* infection, the health professional is responsible for completing the notification/investigation form in SINAN. This step is critical because it enables detailed recording of crucial information, including clinical and laboratory data and classification of the mode of transmission (vectorial, oral, transfusional, congenital, or accidental), which is highly relevant for guiding and controlling epidemiological surveillance actions (BRAZIL, 2021).

The time series from 2013 to 2023 showed a sharp decline in notifications in 2020 (Figure 2), a period that coincides with the onset of the COVID-19 pandemic. This decline may be attributed to factors such as the implementation of restrictive measures (lockdown) adopted to reduce virus spread, as well as the redirection of health actions and resources to address the health crisis, resulting in changes in epidemiological patterns during the period (ZOMAHOUN *et al.*, 2021; SIMEONE & GUIMARÃES-COSTA, 2024). In the subsequent years, notifications again increased, which may reflect the resumption of monitoring and diagnosis of this condition.

The importance of the Evandro Chagas Institute (IEC) in epidemiological surveillance

The high concentration of cases in the state of Pará can also be interpreted in light of the diagnostic capacity and research infrastructure established in the region. The Evandro Chagas Institute (IEC), founded in 1936, plays a strategic and central role in surveillance, reference laboratory diagnosis, and research on endemic diseases, with a special focus on the Amazon Region and, particularly, on Pará (EVANDRO CHAGAS INSTITUTE, 2024). Our hypothesis suggests that the uninterrupted work of the IEC in mapping and epidemiological monitoring of CD over the decades may have facilitated greater active detection with formal case recording. Consequently, the presence and technical robustness of the IEC in Pará may introduce a detection and notification bias, partially explaining the high number of reports when compared to other states in the Northern Region, which may not have a reference institution with a similar history and scope for the surveillance of neglected diseases.

Oral transmission and Chagas Disease

In the period from 2013 to 2023, Brazil totaled 3,571 cases, of which 95.29% occurred in the Northern Region. According to DATASUS data, the predominant modes of transmission were: (1) oral transmission, with 2,891 cases (85% of notifications in the region), followed by (2) vectorial transmission, with 217 cases (6.4%). Given this scenario, we assume a direct relationship with the regional dietary pattern. The state of Pará, as the epicenter of CD in the Northern Region, shows an epidemiological trend closely related to the socioeconomic and productive characteristics of the state, which is nationally recognized as the largest producer and exporter of açaí in Brazil, according to the Foundation for Support to Studies and Research (FAPESPA, 2024).

The expansion of the açaí production chain, driven by growing domestic demand and especially by the increasing export of the fruit, has favored the intensification of extractive activities and artisanal processing. The increase in price, in addition to affecting access by local populations to a traditional and highly nutritious food, highlights how regional economic and productive dynamics can interact with social and sanitary vulnerabilities, indirectly influencing the epidemiological profile of Chagas disease in the state (DIAS *et al.*, 2016). The production of açaí without proper sanitary care represents a major risk for cross-contamination in the final product. Among the preventive handling measures, fruit blanching stands out; this process is carried out by immersing the fruit in water at 80°C for 10 seconds, followed by immediate cooling, with the aim of eliminating pathogenic microorganisms. This measure is required by State Decree No. 326 of January 20, 2012 (PARÁ, 2012). Nevertheless, the high prevalence of oral contamination is discrepant, raising hypotheses of failure in Good Manufacturing Practices (GMP).

Chagas Disease in Pará and age group

The analysis of age distribution showed that the population most affected by CD in Pará was concentrated between 20 and 59 years of age, encompassing the 20–39 and 40–59-year groups, which together represent the absolute majority of notifications in the period from 2013 to 2023. This predominance reflects not only the demographic and productive profile of the region, but also the nature of the oral transmission route.

Young and middle-aged adults constitute the age group with the highest participation in activities related to the production, handling, and consumption of regional foods such as açaí and bacaba—products frequently associated with *T. cruzi* contamination when processed without adequate sanitary practices. In addition, this group tends to have dietary habits and consumption patterns more frequently outside the home environment, which increases the likelihood of exposure to contaminated products originating from small producers and local markets (BRAZIL, 2015; VILHENA *et al.*, 2020).

Therefore, the concentration of cases among individuals aged 20 to 59 can be understood as a reflection of the predominant oral transmission pattern in the state, intensified by sociocultural and economic factors that characterize the Amazonian context, such as the informality of açaí processing, high seasonal consumption, and insufficient sanitary surveillance in the stages of fruit processing (FAPESPA, 2024; CUNHA *et al.*, 2021). This scenario demonstrates that the greater vulnerability of this age group arises not only from occupational aspects but also from dietary and structural behaviors related to the production and commercialization of regional foods, consolidating Pará as the epicenter of Chagas disease notifications in the Northern Region.

5. Conclusion

The analysis of the temporal trend and spatial distribution of Chagas Disease (CD) in the North Region of Brazil between 2013 and 2023 reaffirmed CD as a severe and persistent public health challenge, characterized by marked regional heterogeneity. The findings established Pará as the clear epicenter of the disease, concentrating 79% of all notifications. The temporal curve in Pará, which showed a sharp increase in cases from 2020, culminating in the maximum peak in 2023, signaled a heightened state of alert and the potential worsening of the epidemiological situation.

The high disease burden in Pará was concentrated in specific foci of transmission, notably in the municipalities of Abaetetuba, Breves, Belém, Cametá, and Curralinho, where productive and socio-environmental factors converge. This case concentration in areas of açaí and bacaba handling reflects the predominance of oral transmission, which was the majority mode of contagion in the region. The age distribution highlighted the greater vulnerability of young and middle-aged adults (20 to 59 years), who are more involved in the processing and consumption of these regional foods. Nevertheless, the persistent notification of cases in children and adolescents in Pará and Acre confirmed the existence of active and recent transmission, demanding immediate intervention.

In the other states, the research revealed profiles of low notification, with focal clusters in Amazonas, Amapá, Acre, and Tocantins. The situation in Rondônia and, mainly, in Roraima (0.09% of notifications), strongly suggested the existence of underreporting and structural limitations in the surveillance systems, which obscures the actual magnitude of CD in the region.

Therefore, to mitigate the risk and control the disease in the North Region, it is essential to strengthen primary health care to enhance diagnostic capacity and active surveillance, especially in states with low *per capita* coverage. It is also important to intensify sanitary practices and inspection in the productive chains of regional foods like açaí, promoting compliance with preventive measures, such as the blanching step, in addition to prioritizing resources and strategic public health, research, and surveillance actions for the hotspots identified in Pará and Acre, aiming at the interruption of active transmission and the adequate management of chronic disease.

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