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Clinical-Epidemiological and Spatial Overview of Hospitalizations Due to Infectious Diseases in Southeastern Pará

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ABSTRACT

Introduction: Some infectious diseases that were common in the early twentieth century have reappeared on the global stage, even after having been eradicated or controlled. Thus, the world continues to face threats from longstanding, emerging, and reemerging infectious diseases.

Objective: To determine the clinical, epidemiological, and spatial profile of hospital admissions caused by infectious diseases in the southeastern region of the State of Pará, in the Brazilian Amazon.

Method: An analytical ecological study was conducted using data from 15 municipalities within the 12th Regional Health Center. The information used originated from the Hospital Morbidity tab of the SUS Hospital Information System (SIH/SUS), accessed via its online platform. Data were analyzed using descriptive and inferential statistics, as well as geographic mapping.

Results: Between 2012 and 2022, 399,578 hospitalizations were recorded in the Araguaia health region; of these, 15.0% (60,331 cases) were related to infectious diseases. The ten selected conditions accounted for 94.8% (57,199/60,331) of the total hospitalizations associated with infectious diseases in this region. Regarding diagnosis, 30.8% of infectious disease cases (18,621 of 60,331) did not have a specific diagnostic classification assigned.

Conclusion: Based on these analyses and their comparison with the scientific evidence, there is a need to expand epidemiological surveillance of hospital admissions, to strengthen autonomy at the municipal level, and to conduct further studies in order to establish and provide more reliable data regarding the investigated issue.

Descriptors: Infectious Diseases; Hospitalization; Epidemiological Surveillance; Geographic Mapping.

INTRODUCTION

Several infectious diseases that were common in the early XX century and were controlled in the same century with the advent of vaccines and antimicrobials have been reported again in the XXI century, even after periods of eradication or control, as exemplified by measles.[1] These diseases, classified as reemerging, have been recorded over the years in episodes of outbreaks, epidemics, or pandemics.[1] Some factors contributing to reemergence include the adaptation and changes in microbial virulence factors, human susceptibility to infection (including increased vaccine hesitancy), climate change, demographics, and human behavior (including imported cases), the weakening of public health measures, poverty, and social inequality.[1] In the context of measles, it is important to emphasize that it is a highly contagious disease, with a basic reproduction number (R_0) estimated between 12 and 18. Its recent reemergence is mainly related to the reduction in vaccination coverage, exacerbated by disruptions in health systems during the COVID-19 pandemic, increased vaccine hesitancy, and the fragility of epidemiological surveillance systems in various region.[2]

To corroborate the data, the World Health Organization (WHO) highlighted that the global measles situation worsened severely in 2019, recording the highest number of cases in 23 years (approximately 870,000 infections) and an alarming 50% increase in mortality rate compared to 2016, resulting in over 207,500 deaths in that year alone. This drastic setback is fundamentally due to the failure in vaccinating children with the two recommended doses, as global vaccination coverage stagnated and remained well below the 95% needed to prevent outbreaks.[3] Therefore, infectious diseases globally represent challenges to public health, especially in low-income areas, due to limited resources for mitigation and control actions.[1-3]

Furthermore, it is important to consider the evolution of virulence and pathogenicity of etiological agents, such as the transmitted resistance of the Human Immunodeficiency Virus (HIV), which remains high in Sub-Saharan Africa, despite the participation of local studies decreasing from 29% to 22%. This result reinforces the need for global and equitable initiatives to monitor and contain these diseases.[4] Thus, the pathogens associated with these illnesses possess a high capacity for mutation and evolution, which poses significant challenges to the control of these diseases.[4-5] Consequently, failures in prevention and control strategies may result in increased hospitalization rates.[6] In this regard, the WHO has categorized certain pathologies as priorities due to their high public health risk and epidemic potential.[7]

In this perspective, contemporary civilizations yearn for the development of an efficient global health system to combat these challenges.[8] Nevertheless, the world remains vulnerable to emerging and re-emerging threats, and with the emergence of new drug-resistant strains, infections that were once easily treatable may again cause thousands of deaths. Between 2013 and 2017, in Brazil, infectious and parasitic diseases accounted for the fourth highest number of hospital admissions and ranked third in mortality.[6]

Thus, when considering the biological, epidemiological, and environmental specificities, most of these health problems are classified as Neglected Tropical Diseases (NTDs), a broad group comprising more than twenty illnesses and conditions associated with processes of inequality and increased vulnerability of territories, communities, and individuals in adverse economic, social, and environmental contexts, especially in tropical and subtropical regions. In this context, the One Health approach proposes integrated strategies to address issues involving humans, animals, plants, and the environment, recognizing the complexity of this mitigation.[8]

Moreover, with advancing economic development across Brazil's regions, it was anticipated that this group of pathologies would have a reduced impact on health systems due to increased urbanization, improved urban infrastructure, and the implementation of vaccination programs.[6,9] Despite these advances, cases of emergence and reemergence have been observed, driven by human and biological barriers such as vaccine hesitancy and the capacity of pathogens to evolve. These factors can outpace human and technological speed in vaccine production, as occurred with smallpox, underscoring the severity of these diseases and highlighting the need for strategies based on local and specific indicators.[9–12]

It is noteworthy that most of these infections are vector-borne, demonstrating a direct link to environmental balance. In a study conducted at a university hospital in the Brazilian Amazon region,

approximately 29% of deaths were due to immediate causes related to infectious and parasitic diseases.[13]

In this context, the present study is relevant because it provides local and specific data on the occurrence and distribution of these diseases in a region whose Amazonian climate favors pathogen diversity, while also accounting for frequent environmental disturbances that may contribute to an increased population-level burden. Furthermore, the work offers important support for the national literature and guidance for integrated, effective public policies aimed at the control and mitigation of these pathologies. Therefore, the objective of this study was to determine the clinical, epidemiological, and spatial profile of hospitalizations caused by infectious diseases in the Southeast Region of Pará, located in the Brazilian Amazon.

METHODS

This is an analytical ecological study based on data from the 15 municipalities that comprise the 12th Regional Health Center (Araguaia Region): Redenção, Rio Maria, Bannach, Conceição do Araguaia, Sapucaia, Tucumã, Xinguara, Pau d'Arco, Floresta do Araguaia, Ourilândia do Norte, São Félix do Xingu, Cumaru do Norte, Santana do Araguaia, Água Azul do Norte, and Santa Maria das Barreiras.

The microregion has approximately 454,710 inhabitants and features a superhumid equatorial climate, with a mean minimum temperature of 22.71 °C, a mean maximum of approximately 32.01 °C, and an annual mean temperature of 25.35 °C.[14,15] Relative humidity is high, ranging from 52% in the driest seasons to 90% in the wettest seasons, with a mean of 71%.[14–15]

The dry season occurs between June and October, while precipitation is concentrated predominantly from November to May. The annual rainfall index is approximately 2,000 mm, and the predominant biome in the region is the Amazon.[15] Medium- and high-complexity services for patients from the 15 municipalities are centralized in a single regional public hospital located in the municipality of Redenção, at an average distance of 1,008 km from the state capital, Belém. Regarding basic sanitation, only 15.4% of households have adequate sewage systems.[14–15]

Secondary clinical-epidemiological data from hospital admissions, available in the database of the Department of Information and Informatics of the Unified Health System (DATASUS) via the Tabnet platform under the SUS Hospital Morbidity tab (SIH/SUS), were analyzed. The data obtained during collection were transferred and organized into structured databases in Microsoft Excel 2019. In order to fully address the objectives proposed in this study, the methodological strategy was outlined and conducted as described below:

a) The occurrence of hospital admissions attributed to pathogenic agents in the Araguaia Region of the State of Pará was investigated from 2012 to 2022, based on data from the Hospital Morbidity Information System of the Unified Health System (SIH/SUS).

b) The clinical-epidemiological profile of patients hospitalized for infectious diseases from 2012 to 2022 was characterized by analyzing variables such as age, sex, municipality of admission, and race. Indicators such as the mortality rate, which corresponds to the total number of deaths recorded in the SIH/SUS for each disease group under study, were also examined. The case fatality rate was calculated as the ratio of the number of deaths from a specific disease to the total number of cases of that disease, multiplied by 100, along with the average length of hospital stay and clinical outcomes for each recorded illness. The data were obtained from the Hospital Morbidity Information System of the Unified Health System (SIH/SUS).

c) The ten main health conditions and infectious diseases associated with hospitalization in the Southeast Region of Pará were highlighted (Table 1). Data were sourced from the Hospital Morbidity Information System of the Unified Health System (SIH/SUS). d) The spatial distribution of the main pathologies in each municipality was demonstrated.

Table 1. List of diseases selected and compiled for inclusion in the study.

Disease Group — ICD-10
I- AmebIASIS: - ICD-10: A06
II - Intestinal infectious diseases: Diarrhea and gastroenteritis of presumed infectious origin - ICD-10: A09; Other intestinal infectious diseases - ICD-10: A02, A04, A05, A07, and A08.
III - Tuberculosis: Pulmonary tuberculosis - ICD-10: A15.0, A15.3, A16.0, A16.3; Other respiratory tuberculoses - ICD-10: A17, A19; Remaining respiratory tuberculosis - ICD-10: A17–A19; Tuberculosis of the nervous system - ICD-10: A17; Tuberculosis of the intestine, peritoneum, and mesenteric lymph nodes - ICD-10: A18.3; Bone and joint tuberculosis - ICD-10: A18.0; Genitourinary tuberculosis - ICD-10: A18.1; Miliary tuberculosis - ICD-10: A19; Other specified tuberculoses – ICD-10: A18.2, A18.4, and A18.8.
IV- Septicemia (SepsIS): - ICD-10: A40 e A41.
V- Unclassified bacterial diseases: Other remaining bacterial diseases — ICD-10: A21–A22, A24, A26, A28, A31, A32, A38, A42, and A49.
VI- Arboviral diseases: Dengue (classic dengue) — ICD-10: A90; Dengue hemorrhagic fever — ICD-10: A91; Other specified arboviral fevers and viral hemorrhagic fevers — ICD-10: A92, A94, A96, A99.
VII - Unclassified Viral Diseases: Remaining from other viral diseases - ICD-10: B03, B04, B07, B09, B25, B27, and B34.
VIII. Malaria: Malaria caused by *Plasmodium falciparum* - ICD-10: B50; Malaria caused by *Plasmodium vivax* - ICD-10: B51; Malaria caused by *Plasmodium malariae* - ICD-10: B52; Other confirmed forms of malaria by parasitological examination - ICD-10: B53; Unspecified malaria - ICD-10: B54.
IX - Leishmaniases: Visceral leishmaniasis — ICD-10: B55.0; Cutaneous leishmaniasis — ICD-10: B55.1; Mucocutaneous leishmaniasis — ICD-10: B55.2; Unspecified leishmaniasis — ICD-10: B55.9.
X - Sexually Transmitted Infections (STIs): Congenital syphilis - ICD-10: A50; Early syphilis - ICD-10: A51; Other syphilis - ICD-10: A52 and A53; Gonococcal infection - ICD-10: A54; Sexually transmitted chlamydial diseases - ICD-10: A55 and A56; Other infections with predominantly sexual transmission - ICD-10: A57-A64; Acute hepatitis B - ICD-10: B16; Other viral hepatitis - ICD-10: B15, B17-B19; Disease due to human immunodeficiency virus [HIV] - ICD-10: B20-24.

Source: Prepared by the authors from Tabnet/DATASUS, Ministry of Health / Secretariat of Health Surveillance (SVS), Hospital Information System of the SUS (SIH/SUS).

Spatial analysis was conducted using indexed point vector data, adopting the UTM projected coordinate system referenced to the SIRGAS 2000 geodetic datum, the current official standard in Brazil. In the subsequent step, the kernel density estimator was applied to the distribution of the number of hospital admissions. A standard bandwidth of up to 2.000 meters and a spatial resolution of 200-meter pixels were used. Analyses were performed in QGIS, while cartographic layout preparation was conducted in ArcGIS Pro, *Student* version.

Data were tabulated and presented in Microsoft Excel 2019 tables and consolidated according to the appropriate coding for each studied variable. Statistical analysis was performed using Bioestat 5.0, employing absolute and percentage distributions, means, and standard deviations (descriptive analysis).

Regarding the epidemiological variables presented in Table 2, descriptive statistical tests were performed, and data were reported using measures of central tendency. The G test or Chi-square test of independence, followed by residual analysis, was used to assess the association between different categories of a variable in two independent groups; a p-value < 0.05 was considered significant, using Bioestat 5.3.

To assess the correlation between the environmental and sociodemographic variables (Table 3) and the total number of cases of the diseases analyzed in each municipality, *Spearman's* rank correlation coefficient was calculated using the Bioestat 5.3.0 *software*. The comparison of means between the total number of cases across all municipalities and the variables case-fatality rate (formula: number of deaths divided by number of cases, multiplied by 100), sanitation coverage, gross domestic product (GDP), Municipal Human Development Index (MHDI), Basic Education Development

Index — final years of elementary school — public network (IDEB), and average monthly nominal wage of formal workers [2020] — in minimum wages (Income–SMM) was performed using the t test in Bioestat 5.3. In addition, municipalities with total cases above three thousand (i.e., the extremes) were compared to assess the significance of the association. The indices for sanitation coverage, GDP, MHDI, IDEB, and Income–SMM were obtained from the Brazilian Institute of Geography and Statistics (IBGE) city portal for the period corresponding to the data collection.

The temporal trend from 2012 to 2022 was analyzed using simple linear regression, with annual records as the dependent variable and year as the predictor. The Absolute Mean Annual Variation (AMAV) was based on the slope coefficient (β). The coefficient of determination (R2) assessed model fit, with a significance level of 5% ($p < 0.05$) and 95% confidence intervals (CI). Analyses were performed using Jamovi software (version 2.2).

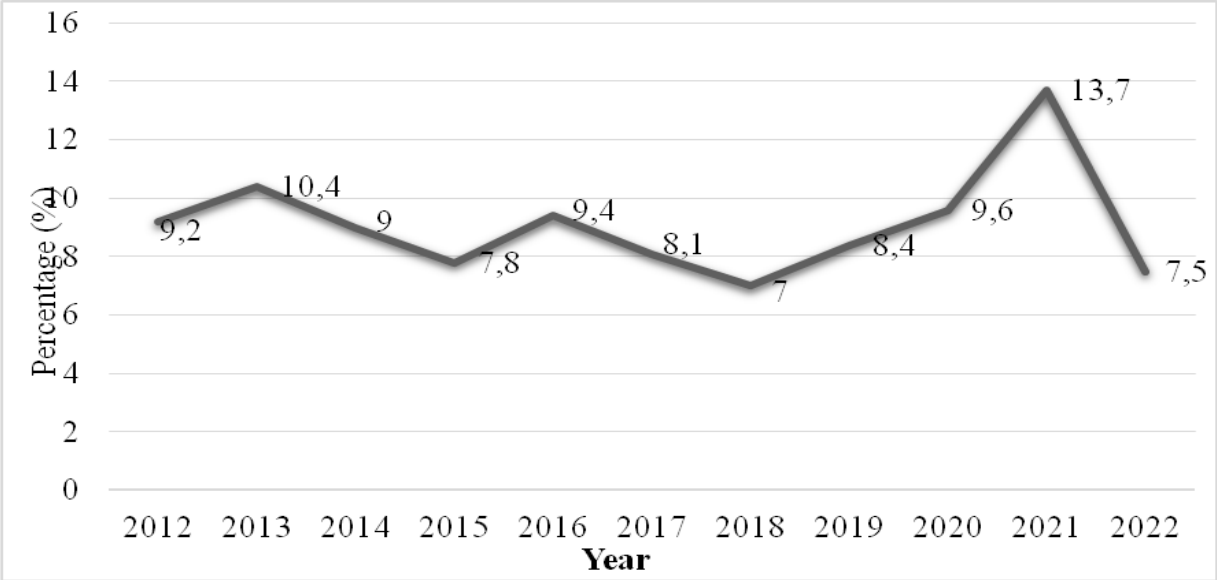
This study did not require submission to the Research Ethics Committee (CEP), in accordance with Resolution No. 466 of December 12, 2012, of the National Health Council (CNS), and the requirement to obtain the Informed Consent Form (ICF) was waived, as it involved public secondary data (SUS Hospital Morbidity — SIH/SUS) that do not permit identification of individuals.

RESULTS

During the study period, 399,578 hospital admissions were recorded in the Araguaia health region, of which 15.0% (60,331/399,578) were related to infectious diseases. The ten selected conditions accounted for 94.8% (57,199/60,331) of the total admissions for this group of diseases in the region. Among them, intestinal infectious diseases stood out, responsible for 40.3% (23,047/57,199) of reported cases, followed by unspecified bacterial diseases, with 19.5% (11,191/57,199), and unspecified viral diseases, which represented 13.0% (7,430/57,199) (Table 1). Considering the temporal analysis, the largest numbers of admissions occurred in 2021, accounting for 13.7% (7,837/57,199), followed by 2013, with 10.4% (5,936/57,199), and 2020, with 9.5% (5,468/57,199) (Figure 1).

The time-series analysis for the years 2012–2022 revealed substantial fluctuation in the absolute number of records, ranging from a minimum of 4,000 in 2018 to a peak of 7,837 in 2021. The simple linear regression model (used to estimate the VAMA) estimated an average increase of 28.2 records per year; however, this variation was not statistically significant ($p = 0.794$; 95% CI: −208 to 265). Consequently, the indicator exhibited a stationary temporal trend over the period analyzed (Figure 1).

Figure 1. Temporal distribution of cases associated with infectious diseases for the period 2012–2022, Southeastern Pará, Brazil.



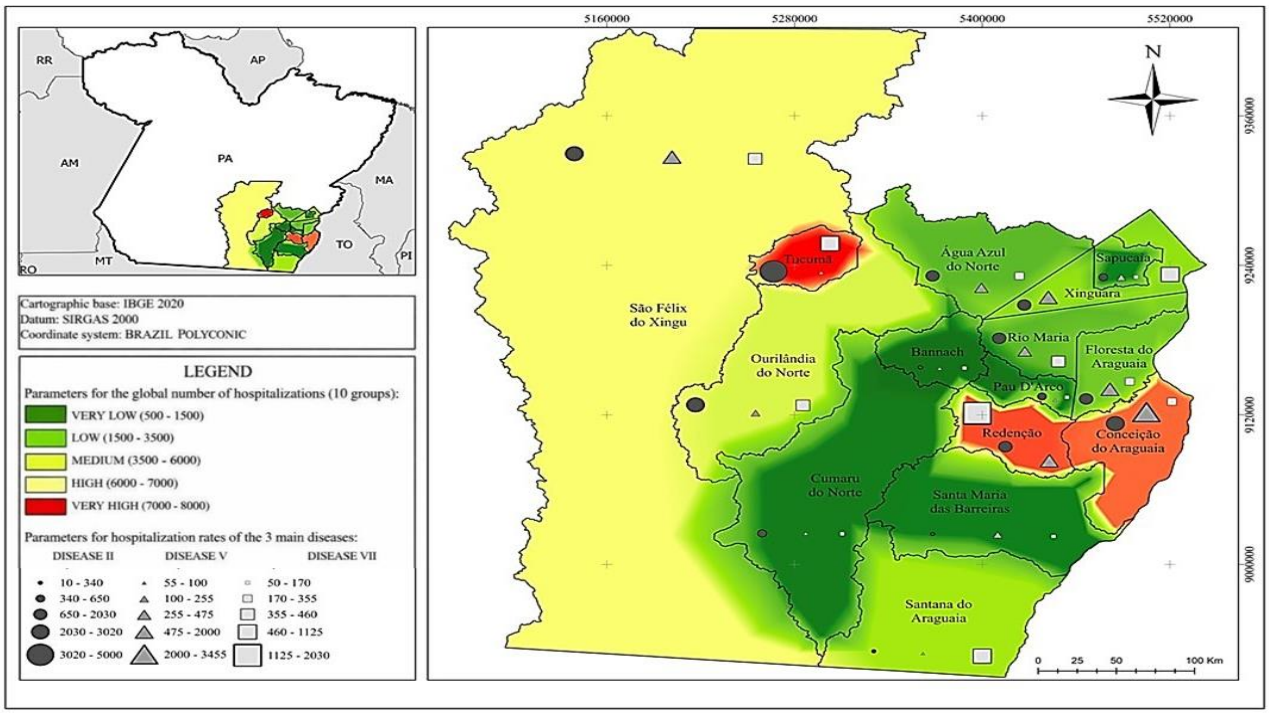
Source: Prepared by the authors (2023).

With respect to the spatial distribution of cases, the municipalities with the highest proportions of hospitalizations associated with these groups of pathologies were Tucumã, with 13.7% (7,828/57,199), followed by Redenção, with 12.6% (7,241/57,199), Conceição do Araguaia, with 12.4% (7,114/57,199), São Félix do Xingu, with 11.0% (6,335/57,199), and Ourilândia do Norte, with 10.2% (5,858/57,199) (Figure 2; Table 1).

Among the disease groups analyzed, intestinal infectious diseases (Disease II) stood out, particularly in the municipality of Tucumã, with 21.2% (4,892/23,047), followed by Ourilândia do Norte, with 13.1% (3,020/23,047), and São Félix do Xingu, with 12.1% (2,790/23,047). Regarding unspecified bacterial diseases (Disease V), the highest occurrence was observed in Conceição do Araguaia, with 30.8% (3,451/11,191), followed by São Félix do Xingu, with 17.8% (2,000/11,191), and Xinguara, with 13.8% (1,555/11,191). Unspecified viral diseases (Disease VII) predominantly affected residents of Redenção, with 27.2% (2,026/7,430), Tucumã, with 15.1% (1,124/7,430), and Xinguara, with 10.5% (786/7,430) (Figure 2; Table 1).

The overall analysis of sociodemographic variables showed a higher concentration of cases in males, accounting for 52.3% (29,922/57,199), in the 20–59 year age group, with 39.8% (22,762/57,199), and among individuals self-identified as pardo (mixed race), with 58.7% (33,575/57,199). It was also observed that nearly all attendances occurred in emergency services, at 99.7% (57,072/57,199). Notably, the variable “type of service” had a high proportion of records coded as ignored/missing, reaching 65.1% (37,262/57,199). Among cases with available information, public care predominated, at 70.1% (13,984/19,937), while the private sector accounted for 29.9% (5,953/19,937). A detailed description is presented in Table 2.

Figure 2. Spatial distribution of the average rate of hospitalizations associated with infectious diseases for the period 2012–2022 in a health region of southeastern Pará, Brazil.



Source: TABNET/DATASUS. Disease II: Intestinal infectious diseases; Disease V: Unclassified bacterial diseases; Disease VII: Unclassified viral diseases.

When analyses were restricted to the specific groups of the most frequent diseases, intestinal infectious diseases were found to occur more frequently in females, accounting for 51% (11,771/23,047), in the 1–14 year age group, with 45.3% (10,441/23,047), and among brown/mixed-race individuals, with 56% (12,911/23,047). It was also observed that 99.8% (22,997/23,047) of cases were treated in emergency services (Table 2).

Unspecified bacterial diseases and unspecified viral diseases were concentrated, respectively, in

males, with 56.4% (6,312/11,191) and 54.5% (4,050/7,430); in the 20–59 year age group, with 47.4% (5,308/11,191) and 56.7% (4,213/7,430); and among brown/mixed-race individuals, with 69.7% (7,808/11,191) and 55% (4,089/7,430). In both groups, care was predominantly provided in emergency services, at 99.7% (11,152/11,191) and 99.9% (7,424/7,430), respectively (Table 2).

Regarding diagnosis, it was observed that, of the total cases associated with infectious diseases, 30.8% (18,621/60,331) did not receive a specific etiological classification. Among the most frequent groups analyzed in this study, 66.7% (2/3) were classified only by the type of pathogen involved, as "unspecified bacterial diseases" and "unspecified viral diseases." In this context, the conditions were recorded solely as bacterial- or viral-origin infections, without identification of the specific etiological agent associated with the clinical presentation.

Table 1. Epidemiological distribution of hospitalizations due to infectious diseases, 2012–2022, in a health region of Southeast Pará, Brazil.

Municipality (n= 57.199)	Infectious diseases n (%)									
	Amebiasis n= 4.402	Intestinal infectious diseases n= 23.047	Tuberculosis n= 230	Sepsis n= 2.932	Unclassified bacterial diseases n= 11.191	Arboviruses n= 5.899	Unclassified viral diseases n= 7.430	Malaria n= 748	Leishmaniasis n= 585	Sexually Transmitted Infections n= 735
AAN (n= 2.356)	3 (0,1)	1212 (5,3)	2 (0,9)	22 (0,8)	385 (3,5)	419 (7,1)	280 (3,8)	9 (1,2)	3 (0,5)	21 (2,9)
B (n= 574)	-	338 (1,5)	2 (0,9)	6 (0,2)	55 (0,5)	86 (1,5)	53 (0,7)	25 (3,3)	1 (0,2)	8 (1,1)
CA (n= 7.114)	1 (0,1)	2388 (10,3)	9 (3,9)	63 (2,1)	3451 (30,8)	700 (11,9)	353 (4,8)	3 (0,4)	82 (14,0)	64 (8,7)
CN (n= 1.088)	109 (2,4)	597 (2,6)	1 (0,4)	93 (3,1)	77 (0,7)	83 (1,4)	95 (1,2)	26 (3,5)	2 (0,3)	5 (0,7)
FA (n= 3.315)	51 (1,1)	1669 (7,2)	5 (2,2)	33 (1,1)	1198 (10,7)	53 (0,9)	289 (3,9)	3 (0,4)	3 (0,5)	11 (1,5)
ON (n= 5.858)	-	3020 (13,1)	12 (5,2)	679 (23,2)	204 (1,8)	1042 (17,7)	457 (6,2)	399 (53,3)	27 (4,6)	18 (2,4)
PD (n= 963)	82 (1,8)	521 (2,3)	5 (2,2)	18 (0,6)	63 (0,6)	80 (1,4)	170 (2,3)	1 (0,1)	11 (1,9)	12 (1,6)
R (n= 7.241)	21 (0,4)	2028 (8,8)	76 (33,0)	909 (31,0)	1148 (10,2)	367 (6,2)	2026 (27,3)	29 (3,9)	363 (62,1)	274 (37,3)
RM (n= 2.305)	1 (0,1)	1126 (4,9)	-	18 (0,6)	475 (4,2)	202 (3,4)	442 (5,9)	10 (1,3)	12 (2,1)	19 (2,6)
SMB (n=1.177)	807 (18,3)	13 (0,5)	4 (1,7)	1 (0,1)	166 (1,5)	102 (1,7)	80 (1,0)	-	1 (0,2)	3 (0,4)
SA (n= 5.131)	3313(75,2)	177 (0,8)	11 (4,8)	363 (12,3)	100 (0,9)	350 (5,9)	721 (9,7)	2 (0,3)	15 (2,6)	79 (10,7)
SFX (n= 6.335)	5 (0,1)	2790 (12,1)	59 (25,7)	293 (10,0)	2000 (17,9)	572 (9,7)	431 (5,8)	75 (10,0)	12 (2,0)	98 (13,3)
S (n= 1.226)	1 (0,1)	651 (2,8)	6 (2,6)	33 (1,1)	256 (2,2)	122 (2,0)	123 (1,6)	2 (0,3)	17 (2,9)	15 (2,0)
T (n= 7.828)	8 (0,2)	4892 (21,2)	1 (0,4)	358 (12,2)	58 (0,5)	1177 (20,0)	1124 (15,1)	146 (19,5)	1 (0,2)	63 (8,6)
X (n= 4.688)	-	1625 (7,0)	37 (16,0)	43 (1,5)	1555 (13,9)	544 (9,2)	786 (10,6)	18 (2,4)	35 (5,9)	45 (6,1)

Source: Tabnet/DATASUS, Ministry of Health/SVS, Hospital Morbidity of the SUS (SIH/SUS) ( ) Numerical data shown as percentages, representing the geographic distribution of infectious conditions. - Numeric value equal to zero not resulting from rounding. HIV = Human Immunodeficiency Virus; AIDS = Acquired Immunodeficiency Syndrome. AAN = Água Azul do Norte, B = Bannach, CA = Conceição do Araguaia, CN = Cumaru do Norte, ON = Ourilândia do Norte, PD = Pau d'Arco, R = Redenção, RM = Rio Maria, SMB = Santa Maria das Barreiras, SA = Santana do Araguaia, SFX = São Félix do Xingu, S = Sapucaia, T = Tucumã, X = Xinguara, FA = Floresta do Araguaia.

Table 2. Sociodemographic profile of hospitalizations associated with infectious diseases from 2012 to 2022 in a health region of Southeast Pará, Brazil.

Sociodemographic variables n= 57.199	Infectious diseases n (%)									
	Amebiasis n= 4.402	Intestinal infectious diseases n= 23.047	Tuberculosis n= 230	Sepsis n= 2.932	Unclassified bacterial diseases n= 11.191	Arboviruses n= 5.899	Unclassified viral diseases n= 7.430	Malaria n= 748	Leishmaniasis n= 585	Sexually Transmitted Infections n= 735
Sex p-value: <0,0001*										
Feminine	2053(46,6)	11771 (51,0)	64 (27,8)	1290 (44,0)	4879 (43,6)	2994(50,7)	3380 (45,5)	211(28,2)	265 (45,3)	370 (50,3)
Masculine	2349(53,4)	11276 (49,0)	166 (72,2)	1642 (56,0)	6312 (56,4)	2905(49,3)	4050 (54,5)	537(71,8)	320 (54,7)	365 (49,7)
Age (years) p-value: <0,0001*										
< 1	406 (9,2)	2641 (11,4)	2 (0,8)	209 (7,1)	458 (4,0)	161 (2,7)	116 (1,5)	5 (0,6)	40 (6,8)	216 (29,4)
1 a 14	2041(46,3)	10.441 (45,3)	14 (6,0)	348 (11,8)	2302 (20,5)	1183(20,0)	277 (3,7)	93 (12,4)	307 (52,4)	136 (18,5)
15 a 19	197 (4,5)	1154 (5,0)	10 (4,3)	126 (4,2)	665 (5,9)	628 (10,6)	166 (2,2)	60 (8,0)	30 (5,1)	46 (6,2)
20 a 59	1244(28,2)	6223 (27,0)	143 (62,1)	1365 (46,5)	5308 (47,4)	3250(55,1)	4213 (56,7)	564(75,4)	169 (28,8)	283 (38,5)
>60	514 (11,6)	2588 (11,2)	61 (26,5)	884 (30,1)	2458 (21,9)	677 (11,4)	2658 (33,7)	26 (3,4)	39 (6,6)	54 (7,3)
P-value breed: <0,0001*										
Brown	2547(57,8)	12911 (56,0)	109 (47,3)	1651 (56,3)	7808 (69,7)	3344(56,6)	4089 (55,0)	427(57,0)	268 (45,8)	421 (57,2)
Black	64 (1,4)	210 (0,9)	13 (5,6)	77 (2,6)	88 (0,7)	54 (0,9)	129 (1,7)	13 (1,7)	5 (0,8)	14 (1,9)
White	154 (3,4)	681 (2,9)	3 (1,3)	87 (2,9)	193 (1,7)	198 (3,3)	341 (4,5)	11 (1,4)	10 (1,7)	16 (2,1)
Indigenous	28 (0,6)	1488 (6,4)	16 (6,9)	115 (3,9)	36 (0,3)	141 (2,4)	95 (1,2)	108(14,4)	9 (1,5)	6 (0,8)
Yellow	10 (0,2)	161 (0,6)	4 (1,7)	13 (0,4)	144 (1,2)	60 (1,0)	256 (3,4)	14 (1,8)	2 (0,3)	11 (1,4)
Ignored	1599(36,3)	7596 (32,9)	85 (36,9)	989 (33,7)	2922 (26,1)	2102(35,6)	2520 (33,9)	175(23,3)	291 (49,7)	267 (36,3)
Complexity of p-value service: <0,0001*										
Urgency	4399(99,9)	22997 (99,8)	230 (100)	2921 (99,6)	11152 (99,7)	5895(99,9)	7424 (99,9)	747(99,9)	585 (100)	722 (98,2)
Elective	3 (0,1)	50 (0,2)	-	11 (0,4)	39 (0,34)	4 (0,1)	6 (0,1)	1 (0,1)	-	13 (1,8)
Type of service p-value: <0,0001*										
Public	2396(	6339	81	619	2624	1294(2	127	99	200	205

	54,4)	(27,5)	(35,2)	(21,1)	(23,4)	1,9)	(1,7)	(13,2)	(34,2)	(27,9)
Private	-	3751 (16,2)	-	180 (6,1)	969 (8,6)	856 (14,5)	6 (0,1)	100(13,3)	12 (2,0)	79 (10,7)
Ignored	2006(45,6)	12957 (56,2)	149 (64,8)	2133 (72,7)	7598 (67,8)	3749(6 3,5)	7297 (98,2)	549(73,4)	373 (63,7)	451 (61,3)
Mortality**										
Number of Deaths (Mortality Rate)	-	59 (0,52)	23 (45,47)	384 (13,10)	185 (1,65)	11 (4,19)	590 (7,94)	-	18 (9,51)	23 (27,09)

Source: Tabnet/DATASUS, Ministry of Health/SVS, SUS Hospital Morbidity (SIH/SUS). Numerical data are shown as percentages, representing the distribution of infectious conditions according to sociodemographic variables. HIV = Human Immunodeficiency Virus; AIDS = Acquired Immunodeficiency Syndrome. AAN = Água Azul do Norte; B = Bannach; CA = Conceição do Araguaia; CN = Cumaru do Norte; ON = Ourilândia do Norte; PD = Pau d'Arco; R = Redenção; RM = Rio Maria; SMB = Santa Maria das Barreiras; SA = Santana do Araguaia; SFX = São Félix do Xingu; S = Sapucaia; T = Tucumã; X = Xinguara; FA = Floresta do Araguaia. *The G test or Chi-square test of independence, followed by residual analysis, was used to test the association between different categories of a variable in two independent groups; p-values < 0.05 were considered significant. **For mortality data, values were retrieved as available from the SUS Hospital Morbidity System (SIH/SUS) and summed according to groups.

With respect to the inferential analyses, no significant correlations were found between the overall total number of cases of the diseases analyzed and case fatality, sewage coverage, GDP, IDHM, IDEB, or average income ($p>0.05$). However, when comparing municipalities with total cases above three thousand — i.e., the extremes (# ¬– CA = Conceição do Araguaia; FA = Floresta do Araguaia; ON = Ourilândia do Norte; R = Redenção; SFX = São Félix do Xingu; S = Sapucaia; T = Tucumã; and X = Xinguara) — significant differences among these variables were observed, as shown in Table 3.

A positive relationship was noted between total cases and case fatality ($p<0.03$), meaning that higher total case counts were associated with higher case fatality rates. In the analysis of total cases and sewage coverage, $p<0.02$ indicated a negative relationship, i.e., higher total case counts were associated with lower sewage coverage. Finally, between total cases and GDP, $p<0.002$ indicated a negative relationship, i.e., higher total case counts were associated with lower GDP (Table 3). The remaining indices did not show significant differences ($p>0.05$) (IDHM, IDEB, and average income).

Table 3. Relationship between the epidemiological distribution of hospitalizations due to infectious diseases and socio-environmental factors in each municipality, 2012–2022, Araguaia Health Region, Pará, Brazil.

Municipalities (n= 57.199)	Sociodemographic and structural aspects						
	Number of inhabitants	Lethality *	Sewage (%)	PIB per capita (R$)	IDHM	IDEB	Income - SMM
AAN (n= 2.356)	18,080	0,72	21,6	19.236,57	0.564	-	2.2
B (n= 574)	4,031	0,87	1,8	30.851,86	0.594	-	2.0
CA (n= 7.114) #	44,617	0,93	4,8	12.955,95	0.640	4.2	2.0
CN (n= 1.088)	14,036	0,37	1,6	29.652,99	0.550	-	2.1
FA (n= 3.315) #	17,898	0,24	1,4	20.176,54	0.583	4.1	2.1
ON (n= 5.858)	32,467	0,87	32,1	23.262,47	0.624	4.4	2.4
PD (n= 963)	6,931	0,31	1,1	17.996,91	0.574	4.0	2.1
R (n= 7.241) #	85,597	12,71	10	23.710,97	0.672	4.4	2.0
RM (n= 2.305)	18,384	1,08	9,5	31.395,51	0.638	-	1.9
SMB (n=1.177)	16,548	0	15,8	33.661,09	0.544	-	2.1
SA (n= 5.131)	32,413	0,04	15	14.967,72	0.602	3.2	2.3
SFX (n=6.335) #	65,418	1,18	22,5	11.939,09	0.594	-	2.5
S (n= 1.226) #	5,847	0,73	2,5	19.013,71	0.590	4.1	1.7
T (n= 7.828) #	39,550	0,98	32,1	21.472,56	0.659	4.5	1.9
X (n= 4.688) #	52,893	0,66	14,3	31.336,01	0.646	3.8	1.8
P – value general análysis		***0,12***	***0,16***	***0,37***	***0,12***	***0,13***	***0,12***
P – value analysis by extremes#		***p<0,03***	***p<0,02***	***P<0,002***	***p > 0,05***	***p> 0,05***	***p > 0,05***

Source: Prepared by the authors (2022). Tabnet/DATASUS, Ministry of Health/SVS: *Hospital Morbidity of the SUS (SIH/SUS); Brazilian Institute of Geography and Statistics (IBGE), 2023. — Numeric value equal to zero not resulting from rounding. "#" Indicates relative frequencies with statistically significant differences ($p < 0.05$) (comparison among municipalities with a total number of cases greater than three thousand). GDP: Gross Domestic Product. MHDI: Municipal Human Development Index. IDEB: Basic Education Development Index (final years of Elementary School — public network). Income - MMW: Average monthly wage of formal workers [2020] — minimum wages. AAN = Água Azul do Norte, B = Bannach, CA = Conceição do Araguaia, CN = Cumaru do Norte, ON = Ourilândia do Norte, PD = Pau d'Arco, R = Redenção, RM = Rio Maria, SMB = Santa Maria das Barreiras, SA = Santana do Araguaia, SFX = São Félix do Xingu, S = Sapucaia, T = Tucumã, X = Xinguara, FA = Floresta do Araguaia.

DISCUSSION

The occurrence of hospitalizations due to infectious diseases identified in this study indicates that, despite records of the epidemiological transition, these conditions persist as a public health challenge in the Brazilian Amazon health region.[8,16] The findings of this survey reveal that communicable diseases continue to exert substantial pressure on the hospital system. Moreover, the predominance of intestinal infectious diseases, the high proportion of nonspecific diagnoses, the spatial concentration of cases in specific municipalities, and the association between a higher number of cases, lower sanitation (sewage) coverage, and lower Gross Domestic Product (GDP) underscore the complexity of this health issue. Although the temporal analysis demonstrated a stationary trend, the maintenance of this burden over a decade indicates the persistence of structural and social determinants.[8]

From this perspective, epidemiological study designs are essential for the control and reduction of neglected tropical diseases, which is evident when observing that 583,960 new cases were recorded between 2016 and 2020 [8]. Additionally, when considering a specific subset of the study area over the analyzed period, the North and Northeast regions exhibited the highest case detection rates.[8] Despite observed national trends toward reduced mortality, the North Region showed a rising trend. Small

municipalities were the most affected by cases and deaths from NTDs, and this condition is directly proportional to the Brazilian Deprivation Index (Índice Brasileiro de Privação, IBP), which underscores how crucial regional epidemiological knowledge is, given the variations arising from epidemiological diversity and, indeed, seasonality.[8,16–17]

A concerning finding is that ten specific conditions accounted for more than 90% of all hospitalizations. This morbidity concentration suggests that, although the spectrum of pathogens in the Amazon is broad, the health system faces epidemiological constraints that could largely be managed at the primary care level.[8,18] This observation underscores the importance of developing prevention policies targeted at the most frequent diagnoses in order to optimize the resources of the 12th Regional Health Center (CRS).[8,18] Accordingly, it highlights the need to promote collaboration among health professionals, ecologists, and biogeographers to improve the quality of data on the distribution of infectious diseases, thereby contributing to the formulation of new health management strategies.[19]

A concerning fact is that ten specific conditions accounted for more than 90% of all hospitalizations. This concentration of morbidity suggests that, although the spectrum of pathogens in the Amazon is broad, the health system faces epidemiological barriers that could largely be managed at the primary care level.[8,18] This finding underscores the importance of developing prevention policies targeted to the most frequent diagnoses in order to optimize the resources of the 12th Regional Health Center (CRS).[8,18] Accordingly, it highlights the need to promote collaboration among health professionals, ecologists, and biogeographers to improve the quality of data on the distribution of infectious diseases, thereby contributing to the formulation of new health management strategies.[19]

Another relevant finding is that the most frequent conditions observed in this study (intestinal infections/amebiasis) were, for the most part, those described in the literature as being associated with lack of water and sewage treatment or with high levels of social vulnerability (IBP).[8,18,20–22] The inadequacy of basic sanitation and limited access to safe drinking water in southeastern Pará are critical determinants that perpetuate cycles of hospitalization for diarrheal diseases and other enteric infections.[20–22]

In the context of Pará, infrastructural deficits converge with environmental dynamics, resulting in hospital morbidity rates higher than those observed in more urbanized and sanitary regions of Brazil [20–22]. There are reports that, even more than a century after its founding, one of the municipalities included in this study still lacks a basic sanitation system, revealing structural vulnerabilities across all components analyzed.[22] Therefore, it is essential to invest in public policies and programs aimed at improving sanitary and environmental conditions, with the goal of mitigating such vulnerabilities and advancing the fulfillment of citizens' basic rights.[8,20–22]

Age-stratified analysis showed that intestinal infectious diseases predominantly affected children and adolescents aged 1 to 14 years, corroborating global evidence that diarrheal diseases remain among the leading causes of hospitalization in the pediatric population.[20] The vulnerability of children in settings with inadequate sanitation and high environmental exposure is well documented and remains significant even in countries with universal health systems, particularly where inequalities persist.[23]

Furthermore, health service utilization among adolescents is lower than in other age groups, while children and older adults exhibit higher service use, which may contribute to lower detection and reporting of clinical cases in this age group and thus influence observed prevalence patterns.[24]

Another condition identified in this study was sepsis, which can be explained by its nature as a potentially fatal pathology that results from an intense and dysregulated systemic host response.[25–26] Therefore, given its high severity and lethality, affected patients frequently require high-complexity services, such as admission to Intensive Care Units (ICUs).[25–26]

Regarding diagnosis, the substantial presence of categories such as unspecified bacterial diseases and unspecified viral diseases suggests limitations in etiological confirmation and weaknesses in the quality of hospital records. This finding may be related to challenges faced in the study region, including the absence of local laboratory infrastructure capable of fully identifying etiologic agents. In addition, the region under study is part of a state with a large territorial extension,

which favors the occurrence of difficulties related to precise diagnosis as well as to control and monitoring actions for these diseases. [27–28]

These gaps in information systems compromise epidemiological surveillance, hinder health planning, and may mask outbreaks or shifts in pathogen circulation patterns.[27–28] In locations with limited laboratory infrastructure, this limitation can result in difficulties in diagnosis and in completing Hospital Admission Authorizations.[27–28]

This underestimation is serious, given the high global mortality from infections. In 2019, there were 13.7 million deaths from infectious causes, of which 7.7 million were associated with 33 priority pathogens; Staphylococcus aureus accounted for more than one million of these deaths.[29] Complete identification of pathogens enables greater precision in therapeutic management, since empirical antibiotic therapy can lead to therapeutic failure, prolonged treatment duration, and increased selective pressure with the potential to intensify bacterial resistance, in addition to contributing to higher costs due to prolonged hospitalization or changes in therapy.[25,30–31]

Similarly, infections of viral etiology also require specific identification, particularly in regions with a high presence of vectors and with environmental and social factors that favor, for example, the occurrence of arboviroses.[32] In this context, it is noteworthy that the global burden of Mayaro fever (MAYV), although it has endemic areas in the Amazon Region, remains largely underestimated due to insufficient adequate and accurate diagnostics.[33–34] Moreover, there is evidence of cocirculation of MAYV and dengue virus in Brazil during 2011–2012, which suggests global expansion of Mayaro fever as well as its underreporting.[34] This scenario highlights the need to improve strategies for case detection, diagnosis, and recording in epidemiological databases.

In addition to these obstacles, the heterogeneous spatial distribution, with case concentrations in municipalities such as Tucumã, Redenção, and Conceição do Araguaia, underscores the complexity of the problem in the region, encompassing demographic, environmental, and organizational nuances. The centralization of medium- and high-complexity hospital services in hub municipalities may contribute to a higher volume of records in those localities.[35–36]

In the study region, a substantial proportion of patients must travel to referral municipalities to access medium- and high-complexity health services, which can lead to delays in diagnosis and treatment and contribute to increased underreporting.[35–36] In this context, it should be emphasized that rapid and accurate diagnosis of infectious diseases is essential, since, when combined with epidemiological surveillance based on reliable data, it can reduce associated morbidity and mortality. [35–36]

Therefore, laboratory tests that are easy to perform, do not require sophisticated resources, and demonstrate high performance should expand diagnostic access—particularly in remote regions—promoting decentralization of services and enabling timely initiation of appropriate care interventions.[35–37] Nonetheless, a study conducted between 2010 and 2017 identified regions characterized by significant economic hardship and issues related to environmental sanitation, factors that contributed to increased incidence of infectious diseases.[38]

From this perspective, this study observed a negative relationship between the total number of cases and the GDP of municipalities with more than three thousand cases; that is, the greater the total number of cases, the lower the GDP, which reflects, at the local level, the importance and necessity of equitable access to quality of life.[39] This finding is consistent with the epidemiological bulletin on DTNs, in which the IBP is directly associated with increases in the number of cases and deaths.[8]

At a global level, the stationary temporal trend observed during the investigated period suggests that, despite annual fluctuations, there was no sustained reduction in hospitalizations for infectious diseases. Moreover, in contexts marked by persistent inequality, the reduction of the burden of transmissible diseases tends to decelerate or stabilize.[8,16,29] This indicates that isolated interventions are insufficient to alter structural patterns; therefore, integrated policies that coordinate health, sanitation, regional development, and social protection are necessary, endorsing One Health actions. [8,16,29]

Thus, the observed increase in 2020 and 2021 may be related to the indirect impacts of the COVID-19 pandemic on health services. The pandemic resulted in disruptions to the provision of essential services, diagnostic delays, and hospital reorganization, affecting the management of various

infectious diseases.[17,40] This context may have contributed both to the rise in hospitalizations and to clinical worsening due to delayed care-seeking. Therefore, the adoption of effective preventive measures is essential, including initiatives such as equitable immunization and the implementation of health education programs aimed at improving personal hygiene practices and ensuring adequate immunological protection.[41–42]

Finally, the study demonstrated that a greater total number of cases is associated with higher lethality. These findings confirm the relevance of the social determinants of health to the profile of hospital admissions.[8,43] In this regard, it is crucial to adopt integrated One Health approaches, as they encompass strategies that consider the interface among human, animal, plant, and ecosystem health, which are essential for addressing this problem comprehensively. This becomes even more important given that the region analyzed is endemic for most of the conditions investigated and has social and environmental determinants that favor the persistence of cases.[8,22,43]

It is important to emphasize that the interpretation of the results requires caution due to two main factors: reliance on the quality of records in secondary databases and the inability to control individual-level confounding variables (ecological fallacy), a characteristic of the ecological design; these issues were mitigated through careful analysis and organization of the data. Nonetheless, such limitations do not invalidate the study's importance, which is notable for its capacity to reveal regional health inequalities. Accordingly, the data should be interpreted as indicators of the collective epidemiological situation, essential for health management. Future supplementation with studies that overcome the barrier of data aggregation is recommended.

CONCLUSIONS

Based on the analysis of the clinical-epidemiological profile of the Araguaia health region between 2012 and 2022, the persistence of the burden of infectious diseases was evident; these accounted for 15.0% of total hospitalizations in the region. The high concentration of hospitalizations in only ten specific conditions suggests potential shortcomings in primary prevention and health surveillance actions at the regional level. In addition, several pathologies were recorded without specific classification, indicating possible diagnostic non-specificity or weaknesses in the notification process. Thus, despite technological modernization, the region still faces challenges typical of socially and environmentally vulnerable settings, in which inadequate sanitation and pressures on and disturbances to the Amazonian ecosystem perpetuate cycles of largely preventable hospitalizations.

In short, the spatial heterogeneity identified underscores the need for decentralized management strategies so that each municipality has equivalent autonomy to control and mitigate cases. Use of the SIH/SUS as a monitoring tool is fundamental for health planning, allowing identification of gaps in care. To reverse this scenario, strengthening Primary Health Care and integrating public policies that improve social determinants are crucial, aiming not only to reduce hospitalizations but to improve the population's quality of life in a holistic manner.

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ORIGIN OF THE ARTICLE

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AUTHORSHIP CONTRIBUTION

Conception and design and/or data collection: Edlainny Araujo Ribeiro, Cássio de Sousa Leal and Enzzo Cavalcante Pereira. Data analysis and interpretation, manuscript drafting and/or critically revising it for important intellectual content and/or final approval of the version to be published: Edlainny Araujo Ribeiro, Cássio de Sousa Leal, Enzzo Cavalcante Pereira, Alanna Oliveira Teixeira, Clarisse Francelino Bastos, Monique Valéria de Lima Carvalhal.

RESEARCH ETHICS COMMITTEE APPROVAL

Study based on information from a publicly available database that did not allow the identification of individuals. Therefore, it did not need to be submitted to the Research Ethics Committee, in accordance with resolution no. 466 of the National Health Council, dated December 12, 2012.

CONFLICT OF INTERESTS

There is no conflict of interest to declare.