Revista ARACÊ
ISSN: 2358-2472

NEGLECTED TROPICAL DISEASES IN THE STATE OF TOCANTINS: EPIDEMIOLOGICAL PROFILE AND HEALTH INDICATORS

https://doi.org/10.56238/arev6n4-369

Submitted on: 11/21/2024 **Publication date:** 12/21/2024

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ABSTRACT

Neglected Tropical Diseases (NTDs) are a set of infectious diseases that mainly affect vulnerable populations in tropical and subtropical regions. This study aimed to analyze the spatio-temporal evolution of the most prevalent NTDs in the state of Tocantins, between 2013 and 2022. This is an epidemiological, descriptive, quantitative and retrospective study. Data from notifications of dengue, leprosy, tegumentary and visceral leishmaniasis, tuberculosis available in the Notifiable Disease Information System (SINAN) linked to the Department of Informatics of the Unified Health System (DATASUS) were used. The variables analyzed provided information on the epidemiological profile (gender, age group, color/race, and education) and health indicators (incidence and prevalence) by health regions of Tocantins. The study revealed that, among the most prevalent NTDs (dengue, leprosy, tuberculosis, cutaneous and visceral leishmaniasis), dengue and leprosy were the most frequent, reflecting trends observed in other regions of Brazil. Dengue was more prevalent among women, while diseases such as leprosy, tuberculosis and leishmaniasis affected more men. The 20 to 39 age group was prevalent for dengue, tegumentary leishmaniasis and tuberculosis, while in leprosy it was 40 to 59 years and visceral leishmaniasis in children 1 to 9 years of age. The self-declared brown race was the predominant race in all the diseases analyzed. Regarding education, dengue affected more individuals with high school education and the other diseases were in individuals with elementary education. Regarding spatiality, the health regions with the highest incidence rates in the period evaluated were Capim Dourado, Ilha do Bananal and Cantão and it was

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related to dengue. NTDs continue to be a challenge for public health, with a complex spatio-temporal evolution. The approach to the control of these diseases must be multifactorial, interdisciplinary and regional, prioritizing equity in access to health care and the improvement of the living conditions of affected populations. Continuous monitoring and prevention are crucial to effectively combat NTDs and improve the quality of life of Tocantins communities.

Keywords: Public health, Incidence, Environmental monitoring, Prevention.

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ISSN: 2358-2472

INTRODUCTION

The most vulnerable populations are subject to Neglected Tropical Diseases (NTDs), because they have precarious conditions of basic sanitation, drinking water and access to health services. According to the World Health Organization (WHO), these factors enable a higher frequency of these diseases (WHO, 2023a).

In Latin America, considering the disability-adjusted years, the following diseases: schistosomiasis, visceral leishmaniasis, leptospirosis and leprosy have the highest burden of tropical diseases. In Brazil, NTDs are considered a public health challenge, affecting more males, with greater frequency in children (under 1 year of age), young people and the elderly (over 70 years of age). NTDs cause morbidity and mortality, even though improvements have been recorded in the years of lives lost due to disability (DALY) (Melo *et al*., 2018).

In Brazilian territory, the regions impacted by NTDs are: North and Northeast, as they have more pronounced social, socioeconomic and structural weaknesses compared to the other regions (Ribeiro *et al.,* 2021). Of the neglected diseases in the state of Tocantins analyzed, in the period from 2013 to 2017, leprosy was the disease with the highest number of reported cases (5,762). This was followed by tegumentary leishmaniasis with 2,390 notifications and visceral leishmaniasis with 1,132 cases. Tuberculosis was the disease with the lowest number of cases (Ribeiro *et al*., 2021).

Leprosy is an infectious disease with dermatoneurological manifestations and a potential degree of disability. It is more prevalent in areas with low socioeconomic conditions and difficulties in accessing health services. It is transmitted by *Mycobacterium leprae*, with high infectivity and low pathogenicity (Brasil, 2023a.)

In developing countries, leprosy is one of the major causes of morbidity, ranking second in the world. Brazil is classified by the WHO as a priority country for leprosy. In 2023, Brazil reported 22,773 cases, remaining in second place in the world ranking (WHO, 2024). According to the Ministry of Health, Brazil has stood out in Latin America, presenting 90% of leprosy cases, thus becoming one of the 23 priority countries for this disease (Brasil, 2023a). The state of Tocantins was one of the three states that did not show a reduction in endemicity in 2010, 2016, and 2021 (Brasil, 2023b).

Cutaneous Leishmaniasis (TL) is an infectious, vector-borne disease caused by the protist of the genus *Leishmania* that affects the skin and mucous membranes (Brasil, 2022a). It is considered by the WHO (2017) to be one of the six most significant infectious

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ISSN: 2358-2472

diseases globally, due to its high detection rate and potential cause of deformities (Brasil, 2017a). Visceral Leishmaniasis (VL) is a chronic, systemic disease caused by the protist genus *Leishmania*, whose transmission occurs through the bite of the infected vector, among which *Lutzomyi longipalpis* stands out in Brazil, which is the main transmitting species followed secondarily by *Lutzomyia cruzi* in the states of Mato Grosso, Mato Grosso do Sul and Goiás. It is one of the most relevant diseases, due to its frequency and high mortality rate (Brasil, 2022a). In 2021, VL had the highest incidence rates in the municipalities: Cavalcante (Goiás), Couto Magalhães, Carmolândia and Pau D'Arco (Tocantins), Uiramutã (Roraima) (Pan American Health Organization (PAHO), 2022).

Dengue is recognized as one of the most significant arboviruses in the Americas. Its occurrence is frequent in countries with tropical and subtropical climates, where climatic and environmental conditions allow the vector to propagate (Brasil, 2022a). Its spread is affected by numerous factors, including the accelerated process of urbanization, environmental and economic aspects, lifestyles, social influences, and cultural elements (Ghorsh; Tiwarl; Chattopadhyay, 2019; WHO, 2023b). In 2022, dengue had the highest incidence rate in the Central-West Region with (2,086.9 cases/100 thousand inhabitants) and the lowest (277.2 cases/100 thousand inhabitants) in the North Region (Brasil, 2023c).

Tuberculosis is a communicable and infectious disease and mainly affects the lungs, but also other organs and systems. Its etiological agent is *Mycobacterium tuberculosis* and it is transmitted by air through the inhalation of aerosols through speech, coughing, and sneezing (Brasil, 2022a). Social vulnerabilities resulting from low socioeconomic status and education are elements that hinder the diagnosis and treatment of tuberculosis. In addition, they contribute to maintaining the active chain of transmission of the disease (Paiva *et al*., 2023). In 2022, the panorama of Tuberculosis in Brazil indicated the municipalities in the Amazon, Roraima, and Rio de Janeiro with the highest risk of illness (Brasil, 2023d).

Territorialization , which is one of the guidelines of the National Primary Care Policy, allows the planning, programming, and execution of actions to be organized according to each territory, due to the determinant and conditioning factors in health being different in each location (Brasil, 2017b). Monitoring and evaluation are essential to identify health problems in each territory and thus direct the actions to be carried out. They are essential tools to guide managers and health professionals for decision-making (Oliveira; Reis, 2018).

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The state of Tocantins has several factors and difficulties in the implementation of actions that lead to the occurrence of NTDs. The tropical climate with high temperatures, poor health care and/or absent in remote locations, delays in diagnosis, low socioeconomic status of the population of Tocantins make it difficult to control these diseases (Ribeiro *et al*., 2021). In this context, the research is justified by the occurrence of NTDs with higher prevalence and incidence in Tocantins (dengue, leprosy, tuberculosis, tegumentary and visceral leishmaniasis). Based on this information, there is a need to establish an epidemiological profile of the population affected by these diseases, especially identifying the health regions with the highest risk of illness in the state. In addition, this study can provide information for managers, allowing the planning of strategies, actions, and prevention and control programs that are more appropriate to the needs of the population to avoid the maintenance of these diseases.

METHODOLOGY

This is an epidemiological, descriptive, quantitative and retrospective study of the neglected diseases prevalent in the state of Tocantins. The study population was obtained from the official database of disease notification: the Disease and Notification Information System (SINAN) of DATASUS. The data refer to cases registered in the last 10 years (2013-2022) of dengue, visceral leishmaniasis (VL) and tegumentary leishmaniasis (TL), tuberculosis and leprosy. For each of the diseases, the variables sex, race, age group and education were analyzed to identify the prevalence and or epidemiological profile of the populations affected by the neglected diseases under study. In the schooling variable, incomplete and complete levels were grouped.

The state of Tocantins is located in the northern region of Brazil and is the newest Brazilian federative unit. It is composed of 139 municipalities and 49% of them have less than 5,000 inhabitants. It consists of eight regions (Mid-North Araguaia, Bico do Papagaio, Cerrado, Cantão, Amor Perfeito, Capim Dourado, Southeast, Ilha do Bananal) and two health macro-regions (Center-South and North) (Figure 1). It has a resident population of 1,511,459 people, with a territorial area of 277,423.627 km2 and a demographic density of 5.45 inhabitants/km². (Tocantins, 2015a; IBGE, 2022). It has a coverage of 93% of primary care (BRASIL, 2023e).

Regarding socioeconomic indexes, the state of Tocantins ranks 4th best in the Gini index in the Amazon region, which measures per capita household income. The Human Development Index (HDI) is 0.731 and the Basic Education Development Index (IDEB), in

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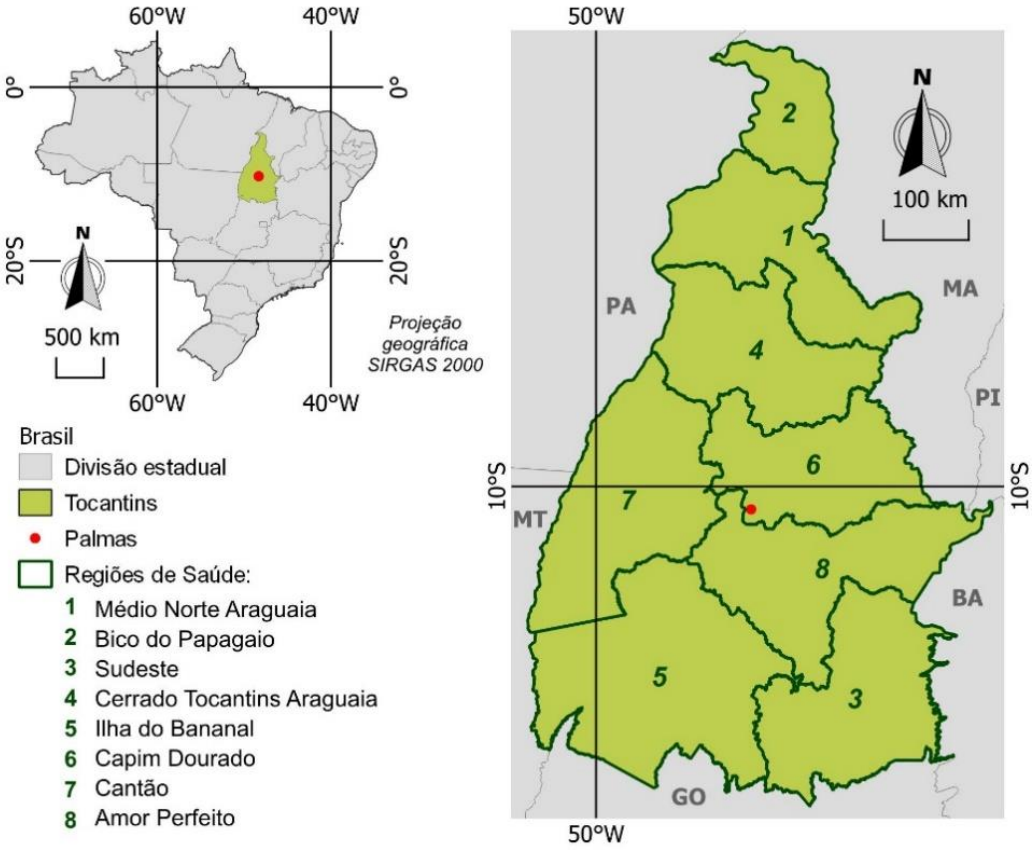
ISSN: 2358-2472

the early years of elementary education in public schools, is 5.1. The demographic census showed that only 28.4% of the population of Tocantins has a sewage system. Regarding water supply, 81.8% of the population has a general distribution network. Household garbage collection benefits 79.02% of the population. As for housing, most of the population lives at home (IBGE, 2022).

Figure 1 – Location of the study area, state of Tocantins, and health regions (2024).



Source: Authors (2024).

The incidence rate is an indicator that uses the number of cases of a given disease divided by the total resident population in the same period multiplied by 100,000 (BRASIL, 2005). For each year analyzed, it was necessary to ascertain the size of the Brazilian population informed by the Brazilian Institute of Geography and Statistics. Prevalence encompasses both new and existing cases, offering a comprehensive view of the total burden of a disease in a population. For the prevalence rate, the formula number of total cases (new and old cases) of a given disease divided by the population in the same period multiplied by 100 was used. For each year analyzed, the size of the Brazilian population informed by the IBGE was verified.

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The maps were prepared in QGIS, a free geoprocessing software. The table with the incidence rate data was associated with the spatial representation file (shapefile), made available by the IBGE - Cartographic Base - Territorial Meshes (IBGE, 2021). The division of the Health regions of the state of Tocantins for the elaboration of the map was removed from the https://portal.conasems.org.br/paineis-de-apoio/paineis/13_macrorregioes-e-regioes-de-saude.

This study was carried out with secondary data, available in a public domain and open access database, in compliance with the ethical principles of Resolution No. 510/2016 of the National Health Council. In this context, submission to the Research Ethics Committee is not necessary.

RESULTS

In the state of Tocantins, the most prevalent neglected diseases between 2013 and 2022 totaled 104,915 notifications. Of these diseases, dengue had the highest percentage (78.21%), followed by leprosy (13.67%), TL (4.20%), tuberculosis (2.12%) and VL (1.81%).

The epidemiological profile of the diseases analyzed (Table 1) allowed us to identify that dengue was prevalent in females (53%) and the other diseases in males (LT - 75.3%; LV - 63%; Tuberculosis - 69% and leprosy - 56%). The 20 to 39 year age group was prevalent for dengue (40%), TL (36%) and tuberculosis (38.63%). In leprosy, individuals aged between 40 and 59 years were prevalent (38%) and the occurrence of VL stood out in children aged 1 to 9 years (31.10%). Among all the diseases analyzed, individuals of self-reported brown race were the most prevalent. Individuals with high school education were more affected by dengue (23%) and in the other diseases, the highest occurrence was in individuals with elementary education.

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Table 1 – Epidemiological profile of the most prevalent NTDs in the state of Tocantins.

VARIÁVEL		DENGUE N(%)	LT N (%)	LV N(%)	TUBERCULOSE N(%)	HANSENÍASE N(%)
Sexo	Masc.	38.518 (46,9)	3.322 (75,3)	1.195 (63,0)	1.531 (69,0)	8.064 (56,0)
	Fem.	43.517 (53,0)	1.086 (24,6)	702 (37,0)	690 (31,1)	6.273(44,0)
	Ig.	16 (0,0)	1 (0,0)	0 (0,0)	0 (0,0)	0 (0,0)
Faixa etária (anos)	<1	1.391 (2,0)	67 (1,5)	226(11,9)	15 (0,7)	0 (0,0)
	01 a 09	9.733 (12,0)	173 (3,9)	590 (31,1)	49 (2,2)	276 (1,9)
	10 a 19	17.386 (21,0)	503 (11,4)	150 (7,9)	131 (5,9)	1.372 (10,0)
	20 a 39	32.605 (40,0)	1.607 (36,0)	430 (22,7)	858 (38,6)	4.197 (29,0)
	40 a 59	15.929 (19,0)	1.325 (30,0)	339 (17,9)	719 (32,3)	5.412 (38,0)
	60 a 79	4.463 (5,0)	634 (14,3)	141 (7,4)	381 (17,1)	2.766 (19,0
	80 e +	534 (0,6)	97 (2,2)	20 (1,0)	68 (30,6)	314 (2,2)
	Ig./Br.	10 (0,0)	3 (0,0)	1 (0,0)	0 (0,0)	0 (0,0)
Raça	Branca	12.728 (16,0)	589 (13,3)	133 (7,0)	269 (12,1)	1.968 (14,0)
	Preta	4.103 (5,0)	415 (9,4)	80 (4,2)	211 (9,5)	1.895(13,0)
	Amarela	2.408 (3,0)	54 (1,2)	6 (0,3)	44 (1,9)	632 (4,4)
	Parda	59.712 (73,0)	3.028 (69,0)	1.645 (87,0)	1.471 (66,0)	9.445 (66,0)
	Indígena	409 (0,5)	217 (4,9)	11 (0,6)	188 (8,4)	130 (0,9)
	Ig./Br.	2.691 (3,0)	106 (2,4)	22 (1,1)	38 (1,7)	267 (1,8)
Escolaridade	Analf.	756 (0,9)	180 (4,1)	52 (2,7)	145 (6,5)	985(6,8)
	EF	21.462 (26,1)	1770 (40,1)	549 (28,9)	953 (42,9)	6.089 (42,8)
	EM	26.541 (33,3)	1.011 (22,9)	274 (14,4)	470 (21,1)	3.603 (25,1)
	ES	9.078 (11,0)	189 (4,3)	47 (2,4)	149 (6,7)	966 (6,7)
	Ig./Br.	15.916 (19,4)	1.095 (24,8)	226 (11,9)	456 (20,5)	2.597 (18,1)
	NSA	8.298 (10,1)	164 (3,7)	749 (39,4)	48 (2,1)	97 (0,7)

Source: DATASUS (2023). Lgenda: EF – elementary school; EM – high school; ES – higher education; Ig – ignored; Br – blank

The incidence of dengue was the highest with 1270.40 cases/100 thousand inhabitants in 2022. Leprosy had an incidence above 100 cases/100 thousand inhabitants between 2016 and 2019. Tuberculosis, TL and VL had a lower incidence of 100 cases/100 thousand inhabitants. in the historical series (Figure 2).

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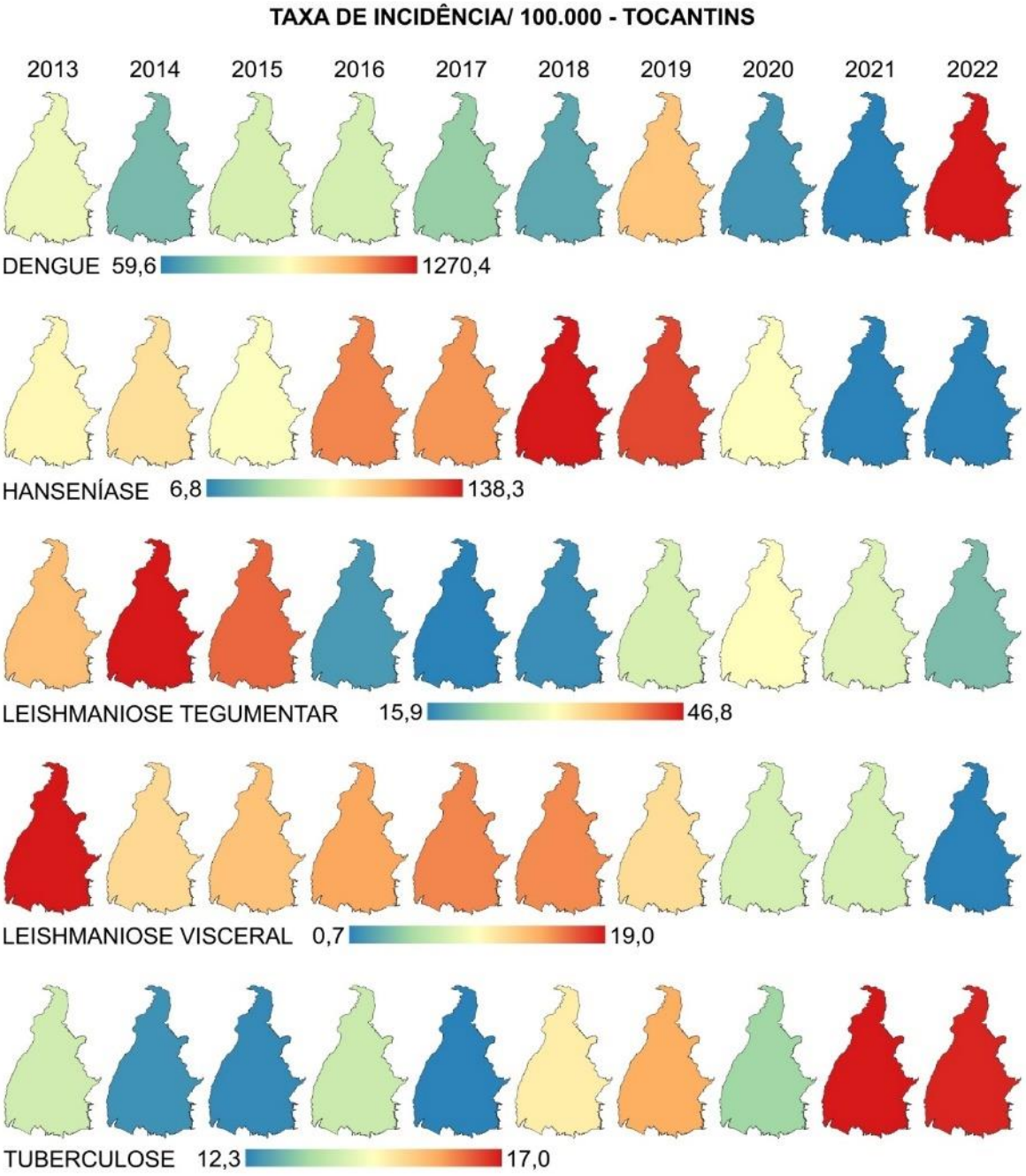
Figure 2 - Temporal evolution of the incidence of dengue, visceral and tegumentary leishmaniasis, tuberculosis, and leprosy diseases in the state of Tocantins from 2013 to 2022.



Source: Authors (2024).

Considering the health regions (Table 2), it was observed that dengue, TL and leprosy had the highest percentage in the Capim Dourado region. The TL showed a homogeneous variation in the regions Médio Norte, Araguaia, Bico do Papagaio, Cerrado, Tocantins, Araguaia, Cantão and Amor Perfeito. The prevalence of VL was in the Middle North Araguaia region, but with the Capim Dourado and Bico do Papagaio regions also standing out. Tuberculosis was more recurrent in the Capim Dourado and Médio Norte Araguaia regions.

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Table 2 – Absolute number and prevalence of dengue, tegumentary and visceral leishmaniasis, tuberculosis, and leprosy between 2013 and 2022 in the health regions of Tocantins.

Health Region	dengue fever n(%)	IT n(%)	LV n(%)	tuberculosis n(%)	leprosy n(%)
Middle North Araguaia	11.503 (14,0)	556 (12,6)	590 (31,0)	463 (21,0)	1.901 (13,0)
Parrot's Beak	3.945 (4,8)	577 (13,1)	319 (16,8)	247 (11,2)	965 (7,0)
Southeast	4.475 (5,5)	378 (8,6)	65 (3,0)	165 (7,4)	548 (4,0)
Tocantins Araguaia Closed	3.832 (5,0)	601 (14,0)	208 (11,0)	190 (9,0)	1.276 (9,0)
Bananal Island	7.745 (9,4)	275 (6,2)	125 (6,6)	220 (9,9)	1.577 (11,0)
Golden Grass	38.740 (47,0)	868 (19,7)	320 (16,9)	529 (23,8)	5.742 (40,0)
Canton	6.250 (8,0)	547 (12,4)	135 (7,1)	229 (10,3)	1.175 (8,2)
Perfect Love	5.561 (7,0)	607 (13,8)	135 (7,1)	178 (8,0)	1.153 (8,0)
Tocantins	82.051	4.409	1.897	2.221	14.337

Source: Authors (2024)

In all health regions, cases of these diseases were reported. It was observed that the regions with the highest dengue incidence rates in the period evaluated were the Capim Dourado, Ilha do Bananal and Cantão regions. For the Central-South macro-region composed of the regions: Capim Dourado, Ilha do Bananal, Amor Perfeito, Cantão and Southeast, the highest incidence rate was for dengue in the Capim Dourado region (3,383.25/100 thousand inhabitants) in 2022. In the North macro-region, composed of the regions: Middle North, Araguaia, Bico do Papagaio, Cerrado, Tocantins, Araguaia, the highest incidence rate was in 2019, with dengue (660.24/100 thousand inhabitants) in the Middle North Araguaia region.

According to the type of transmission of the five diseases analyzed in this study, it was possible to group them taking into account this criterion. Considering vector transmission, there is dengue, TL and VL. Dengue has been more worrisome in the health regions of Capim Dourado, Cantão and Amor Perfeito, with the last few years presenting an incidence above 1000 cases per 100 thousand/inhabitant. (Figure 3). And punctually in a single year, Ilha do Bananal (2013) and Sudeste (2019). Dengue showed the same movement, between 2018 and 2020, in all health regions.

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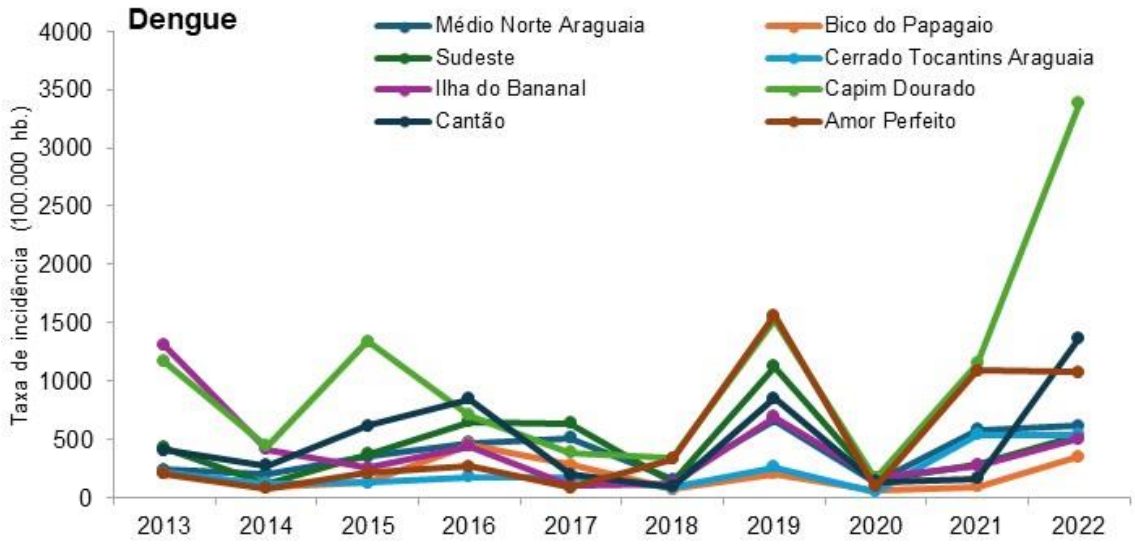
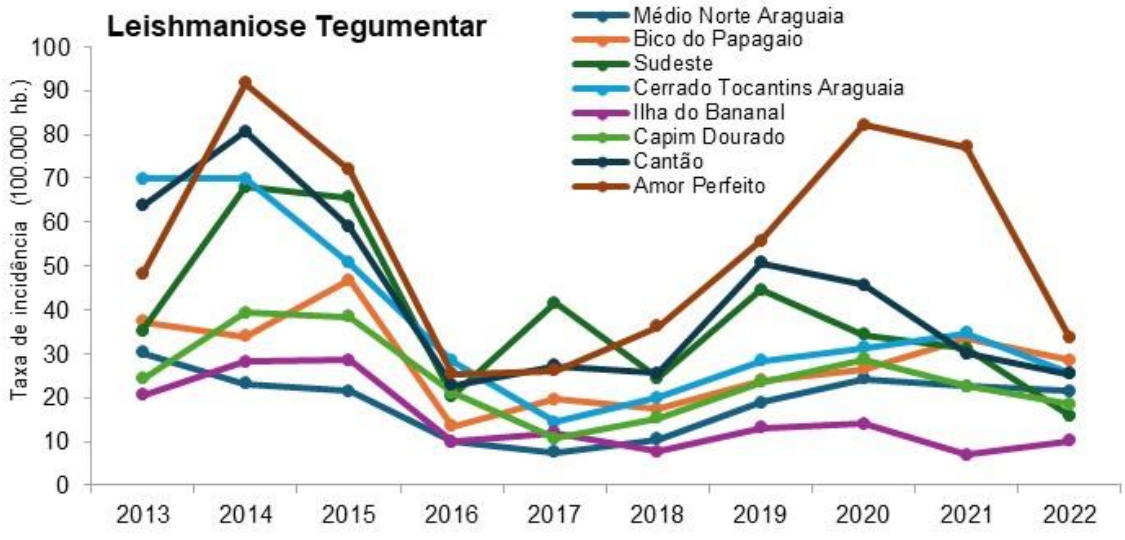
Figure 3 – Historical series of dengue in the health regions of the state of Tocantins, between 2013 and 2022.



Source: Authors (2024)

Cutaneous Leishmaniasis did not present an incidence above 100 cases/100 thousand inhabitants. The highest record was 91.75 cases/100 thousand inhabitants, in the Amor Preprefeito health region. The year 2014 was the most critical in the time series, as it had the highest incidences in six health regions (Southeast, Cerrado, Tocantins, Araguaia, Ilha do Bananal, Capim Dourado, Cantão and Amor Perfeito). Cutaneous Leishmaniasis was also highlighted in the Amor Perfeito region in 2020 and 2021 (Figure 4).

Figure 4 – Evolution of the occurrence of Cutaneous Leishmaniasis in the health regions of the state of Tocantins, between 2013 and 2022.



Source: Authors (2024)

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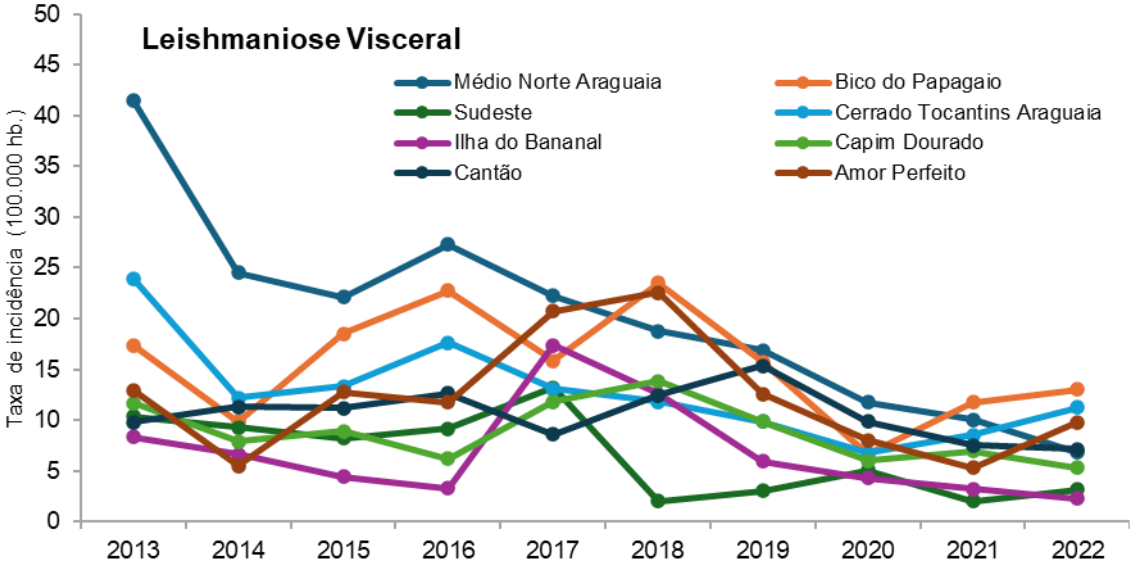
Visceral Leishmaniasis had an incidence above 20 cases/100 thousand inhabitants. in the Middle North Araguaia (41.50) and Cerrado Tocantins Araguaia (23.92) regions, both in 2013. The regions Bico do Papagaio (23.54) and Amor Perfeito (22.57) both in 2018. From 2021 onwards, an upward trend can be observed in the Bico do Papagaio, Cerrado, Tocantins, Araguaia, and Amor Perfeito regions (Figure 5).

Figure 5 – Evolution of the occurrence of Visceral Leishmaniasis in the health regions of the state of Tocantins, between 2013 and 2022.



Source: Authors (2024)

Considering the transmission of diseases by saliva droplets, tuberculosis and leprosy are available. The highest incidences of Tuberculosis (above 20 cases/100 thousand inhabitants) occurred in the Southeast and Amor Perfeito in 2018, Ilha do Bananal and Cantão in 2019 and again in Cantão in 2022. The highlight was the Canton health region, with the highest incidence in the time series (32.60 cases/100 thousand inhabitants) (Figure 6).

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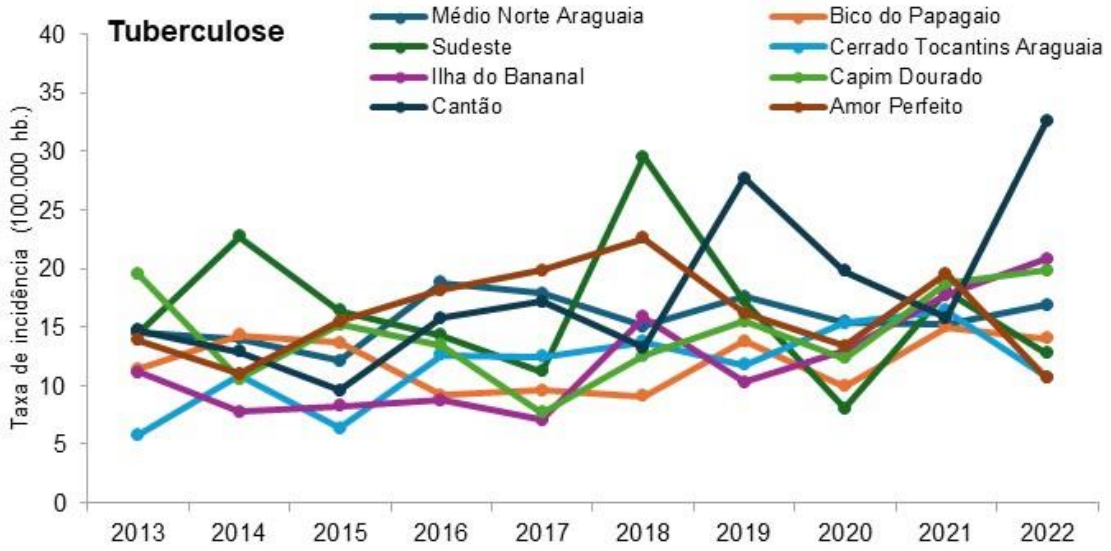
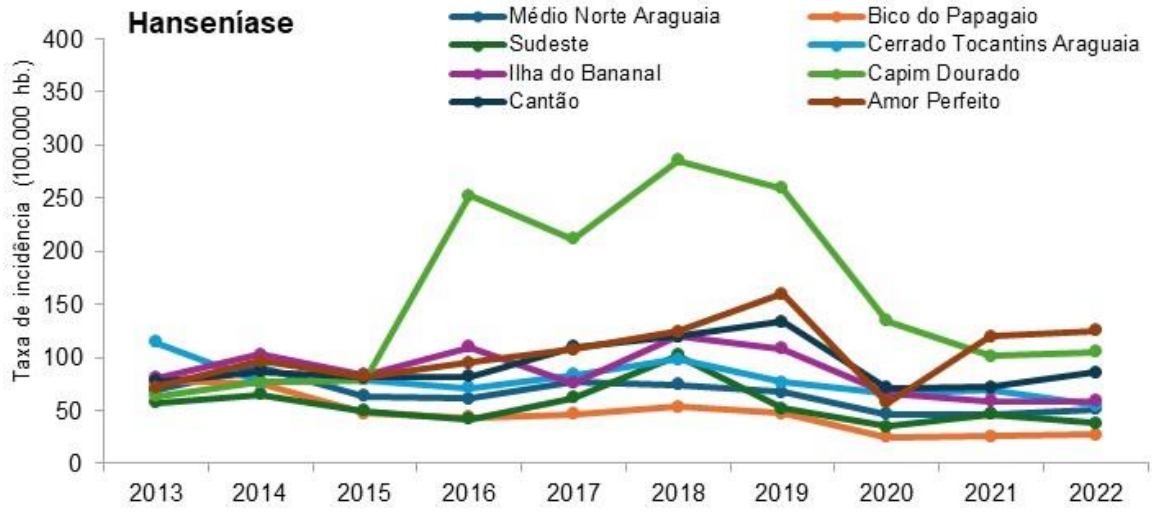
Figure 6 – Historical series of Tuberculosis in the health regions of the state of Tocantins, between 2013 and 2022.



Source: Authors (2024)

The analysis of leprosy among the Health Regions of Tocantins (Figure 7) allowed us to identify that Golden Grass showed a growth above the other regions, between 2016 and 2019 and a subsequent decrease until 2021. The Cantão and Amor Perfeito regions showed the same movement as Capim Dourado, but with growth from 2017 and with lower incidences.

Figure 7 – Historical series of leprosy in the health regions of the state of Tocantins, between 2013 and 2022.



Source: Authors (2024)

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DISCUSSION

The WHO listed 20 diseases as neglected tropical diseases caused by different pathogens (Engels, 2020; WHO, 2020). The main NTDs present in the Americas are: dengue, leprosy, leishmaniasis, schistosomiasis, rabies, scabies, Chagas disease, and intestinal parasitosis (WHO, 2022). The increase in cases of these conditions may be related to the lack of drinking water, basic sanitation and access to health services guaranteed by the Federal Constitution. Most NCDs are considered preventable and preventable (Meurer; Coimbra, 2022).

Regarding the notifications of NTDs analyzed in the state of Tocantins, dengue and leprosy were the diseases with the highest number of notifications. This result corroborates the data presented by Schröder *et al*. (2024), in the Brazilian regions.

Based on the epidemiological profile of NTDs, dengue was more prevalent in females and other diseases in males. This relationship is corroborated by other studies (Rodrigues *et al.,* 2020; Queiroz *et al*., 2022; Santos *et al.,* 2022; Marcula *et al.*, 2023; Schröder *et al.,* 2024). The prevalence of dengue in females may be related to the longer stay of women in the residence and there may be a greater concentration of A*. aegypti foci* (Santos *et al*., 2018; Lima Filho *et al*., 2022). Leprosy was predominant in males (Tavares, 2021; Fields; Silva, 2022; Carvalho *et al.*, 2024), which may be linked to the fact that men have less access to health services (Brasil, 2018). Regarding leishmaniasis, the prevalent sex was male (Abraão *et al*., 2020; Scott; Schröder; Silveira, 2021; Lopes *et al.*, 2022; Ribeiro et al., 2023). Men are more susceptible to exposure to the mosquito because they work longer in the external professional environment, thus increasing their exposure to the vector (Murback *et al.*, 2011). The predominance of tuberculosis in males has also been found in other studies (Silva *et al.*, 2020; Marcula *et al.,* 2023), which can be justified by differences in the immune response to infections (Mussá *et al*., 2018). In the aggravations, dengue, TL, VL and tuberculosis were prevalent in individuals aged 20 to 39 years. The same age group recorded in other studies (Ferreira; Grandson; Mondini, 2018; Rodrigues *et al*., 2020; Silva *et al*., 2022; Oliveira *et al*., 2023; Marcula *et al.*, 2023). Leprosy had a higher percentage of patients between 40 and 59 years of age. Studies carried out in Tocantins showed that this disease was predominant in individuals aged 30 to 49 years (Campos; Silva, 2022) and from 30 to 59 years old (Carvalho *et al.*, 2024). Regarding the self-declared color/race of individuals affected by the diseases, it was possible to verify that in all of them, brown was the most prevalent, a fact evidenced in other studies (Santos *et al*.,

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2018; Brazil, 2020a; Silva *et al.*, 2022). This can be justified by the fact that the population of Tocantins is composed of 62.2% of individuals of brown color/race (IBGE, 2022). Regarding the schooling variable, a higher prevalence of dengue was observed in individuals with high school education. In other diseases with elementary school level. Both data have been evidenced in other studies (Leal *et al.*, 2024; Silva *et al.,* 2024).

Considering the health regions, Capim Dourado was the one with the highest prevalence rates for all the diseases analyzed here, except VL. It is the most populous and most centralized in the state of Tocantins, corresponding to 25% of the state (IBGE, 2022). This region had a higher percentage of notifications of diseases transmitted by personal contact (leprosy and tuberculosis). These data can be justified by the higher population density of this region. In addition, the capital Palmas, which is its largest city, has a large part of the notifications (Martins *et al.*, 2022; Fields; Silva, 2022). A factor that justifies the increase in leprosy cases in some municipalities was the migratory process to the most populous municipalities in the state, such as Palmas, Araguaína and Gurupi. Migratory populations are more susceptible to neglected tropical diseases such as leprosy (Monteiro *et al.,* 2017). The result linked to vector-borne diseases such as dengue and tegumentary leishmaniasis may be linked to climatic conditions favorable to mosquito proliferation and sanitary sewage. Of the arboviruses, dengue was the one that most affected the municipality of Palmas (2015 and 2020), and 90% of the notifications came from the urban area in locations with low infrastructure and sanitation (Queiroz *et al.,* 2022).

Based on the incidence rates of the diseases analyzed in the historical series, in the state of Tocantins, it was observed that dengue and leprosy had the highest incidences. The Capim Dourado, Ilha do Bananal and Cantão regions, which correspond to 45% of the population of the state of Tocantins (IBGE, 2022) had the highest incidence rates. The Cantão health region borders Capim Dourado and Ilha do Bananal, but the Amor Perfeito Health region is centralized between them and did not present a high incidence rate (Tocantins, 2015b). This scenario can be justified by a correlation between socioeconomic variables and the high incidence of leprosy cases (Monteiro *et al.*, 2017).

Regarding dengue, climatic and environmental conditions should be observed. In this context, the state of Tocantins is part of the Amazon Region, having the largest hydrographic basin in Brazil formed by the Tocantins and Araguaia rivers. It has cerrado vegetation as the most prevalent in the state and a small percentage of Amazon transition forest. Half of the state is made up of preservation and conservation regions and

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hydrographic basins. The Bananal Island region has the largest river island in the world. The Canton region is formed by cerrado, pantanal and Amazonian vegetation (Tocantins, 2024). In 2022, Tocantins was considered the state with the highest native destruction due to deforestation, showing an increase of 20% compared to 2021 (IPAM, 2022). In a study carried out in Lake Palmas, the disappearance of the original vegetation due to the flooding caused by the hydroelectric plant was identified, a reduction of 28.56% in native vegetation and an increase in the urban center of the city (Oliveira; Pelúzio; Silva, 2019).

In the capitals of the Brazilian Amazon, there is an occurrence of dengue seasonality. Belém, Palmas, Rio Branco and Manaus have peaks of the disease from January to March and in Boa Vista and Roraima with occurrence throughout the year (Moraes *et al*., 2019). In a study carried out in Palmas, from 2015 to 2017, the seasonality of dengue occurrence was from November to May (Rodrigues *et al*., 2020). *The* mosquito is urban with preferential habits It resides in internal and external environments of homes and establishments. The proliferation of the mosquito increases with high temperatures and rainfall (Brasil, 2022a). As for dengue notifications in the state, the year 2022 was the year with the highest incidence in the time series. The increase in cases in the first four months of the year is expected due to the epidemic period, which correlates with the rainy season in the state. When compared to the first four months of 2021, there is a relevant increase in cases in all Health regions, which may be linked to above-average rainfall, fragmentation of health services as a result of the COVID-19 Pandemic, technical advice for priority municipalities, clinical management qualification workshops and workshops to organize surveillance actions. The reduction in cases in the second four months is expected due to the drought of this period and seasonality (Tocantins, 2023). Among the guidelines for the prevention and control of dengue in primary care, the identification and elimination of breeding sites through vector control, health education actions for the population, home visits by community health and endemic agents, adequate health care with staging of cases and notification of suspected cases (Brazil, 2009). The actions carried out within the scope of surveillance are the monitoring of viral circulation, identification of areas with higher risks, notification of cases, and carrying out prevention and control actions (Brasil, 2022). The cycle of home visits is an action where some properties in the area are selected for vector control. It is considered one of the strategies for vector prevention and control, carrying out eight annual cycles, and 81 municipalities carried out at least eight cycles of home visits (58.27%). The goal established by the Ministry of Health is 70%. It is observed that of the

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14 municipalities that make up the Capim Dourado region, the region with the highest incidences, half of the municipalities, including the capital Palmas, did not carry out eight complete cycles (Tocantins, 2023).

In Leishmaniasis, the protist *Leishmania* is the etiological agent of transmission and has sandflies as a vector. These insects have mainly nocturnal habits, manifesting themselves in peri- and intra-domiciliary environments (Brasil, 2014, Brasil, 2022a). There is a relationship between cases of Leishmaniasis and climatic and environmental variables. Humidity, precipitation, and temperature are environmental factors that influence the reproduction of the vector and consequently may be related to the increase in cases (Reis *et al*., 2019; Coast; Scott; Schröder, 2024). TL has a predilection for mucosa and skin, with wild animals as reservoirs (Brasil, 2022a). Considering the health regions, the TL did not present an incidence above 100 cases/100 thousand inhabitants. during the period studied. In the historical series, the year 2014 was the most critical, as it presented the highest incidences in six health regions (Southeast, Cerrado, Tocantins, Araguaia, Ilha do Bananal, Capim Dourado, Cantão and Amor Perfeito). This result corroborates the study carried out in the state of Tocantins, where a heterogeneous division was evidenced. The highest percentage of TL was recorded in the Cantão, Capim Dourado, Amor Perfeito, Ilha do Bananal and Sudeste regions (southern region of the state) and the highest percentage of VL in the regions of Bico do Papagaio, Médio Norte Araguaia and Cerrado Tocantins Araguaia (northern region of the state). This division between health regions demonstrated that zoonoses are associated with development and urbanization and not exclusively with rural areas (Rodrigues; Viana; Bastos, 2021). The highest incidence rate of VL recorded in this study was found in the Middle North Araguaia region (41.25 cases/100 thousand inhabitants) in 2013. A similar result was evidenced in a study carried out in the north of Tocantins, with the highest incidence of cases recorded in the health regions Bico do Papagaio, Médio Norte Araguaia and Cerrado Tocantins Araguaia (Reis *et al.,* 2019, Rodrigues; Viana; Bastos, 2021).

Environmental conditions have an impact on vector-borne diseases. The climate of the state of Tocantins is predominantly semi-humid tropical, with an average annual temperature of 25ºC to 32.5ºC and minimums of 20ºC to 22ºC (Tocantins, 2015a), characterized by two seasons: the rainy season (November to April), and the dry period (May to October). During the rainy season, temperatures are milder and the relative humidity of the air is high. In the dry season, temperatures can reach higher levels and air

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humidity decreases, resulting in hotter and drier conditions (IBGE, 2022). The climatic factor with high temperatures and low humidity may be related to the high incidence and prevalence of dengue and leishmaniasis cases. Tidman, Abela-Ridder, Castañeda (2021), stated that changes in climatic factors can contribute to the reappearance of NTDs, especially those that are transmitted by vector. According to the WHO, 17% of infectious diseases are transmitted by vectors, causing intense mortality annually. Most of these diseases can be avoided by using prevention measures (WHO, 2020).

Among the diseases transmitted by droplets, leprosy and tuberculosis stand out, which are diseases transmitted as a result of infections that spread through respiratory particles containing virus eliminated by an infected person when talking or sneezing (Brasil, 2022a). Regarding leprosy, in 2017, the national average detection rate in children under 15 years of age was 3.68 new cases/100,000 inhabitants. and in Tocantins it was 22.3 new cases/100,000 inhabitants, keeping the state in 2nd place in the national ranking that year (Tocantins, 2019). The occurrence of cases in children under 15 years of age indicates that the transmission of the disease is active (Brasil, 2022a). In 2018, the state of Tocantins had the highest incidence of leprosy cases during the analyzed period and showed an increase of 34.6% in new cases in the detection rate compared to 2017. This may have been influenced by actions carried out by the technical areas with training for health professionals, mobilization of municipalities to carry out an active search for contacts for dermatoneurological evaluation, and the contemplation of the Roda Hans Project, a partnership between the Ministry of Health and Novartins (Tocantins, 2019). Another action implemented to reduce the transmission of the disease from 2016 to 2018 was the establishment of RuleNo. 32, of June 30, 2015, by the Ministry of Health, which instituted the PEP-HANS project. In this study, post-exposure chemoprophylaxis (PEP) with rifampicin was incorporated into the contacts of leprosy patients in the states of Tocantins, Mato Grosso and Pernambuco. However, in 2020, the National Commission for the Incorporation of Technology in the Unified Health System (CONITEC) suggested the exclusion of rifampicin for contact prophylaxis, due to the completion of the project, which had a completion deadline set in an ordinance for the year 2018 (Brasil, 2020b; Brazil, 2015). In 2020, the state of Tocantins had an incidence of 53.95 new cases/100 thousand inhabitants. ranking it as second in the country. Its capital, Palmas, belonging to the Capim Dourado Health region, stood out with the highest rate (118.51 cases/100 thousand inhabitants) among Brazilian capitals (Brasil, 2022b). These data corroborate the results

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found in this research, where the Capim Dourado region showed growth above the other Health regions, probably due to the high population contingent found in Palmas.

The indicator number of new cases of tuberculosis has a positive polarity, that is, the more cases that are diagnosed, the better it will be for the population, thus allowing early treatment in a timely manner, with the aim of reducing the transmission of the disease (Tocantins, 2022). The incidence was lower than 100 cases/100 thousand inhabitants. in the historical series in all health regions showed a satisfactory result in the State, which may be related to the intensification in the active search for respiratory symptomatics (Tocantins, 2023). Incidence rates below the national parameter for tuberculosis may be associated with the implementation of prevention measures in public policies and socioeconomic differences from one region to another (Pirett *et al.*, 2023). At the federal level, the National Plan for the End of Tuberculosis as a Public Health Problem was implemented by the Ministry of Health, in order to reduce the incidence of tuberculosis (<10 cases/100 thousand inhabitants) and mortality (< 1 death/100 thousand inhabitants) by the year 2035 (Fortuna; Soares, 2020).

Considering the historical series, the year 2020 was a highlight, as it was the beginning of a pandemic period. This year, it was possible to observe a reduction in notifications of all diseases due to the COVID-19 pandemic. This caused underreporting, which may be related to health restrictions during the pandemic period. Essential health services related to NTDs were most affected by the COVID-19 pandemic. The main consequences for public health in this pandemic period were: increase in NTDs, in terms of mortality and morbidity; delays in meeting the public health goals established for the most relevant NTDs, including elimination as a public health problem, transmission and eradication; reduction in the collection, analysis, and use of epidemiological data for planning purposes in all public spheres (WHO, 2021). As a result of this pandemic, many studies that were being carried out on NTDs were suspended in 2020 and resumed later, resulting in delays in the advancement of knowledge about these pathologies (WHO, 2022).

CONCLUSION

When analyzing neglected tropical diseases in Tocantins, a higher endemicity for dengue and leprosy was observed. This study allowed us to identify the epidemiological profile of those affected in the state of Tocantins, with greater involvement in males, with the exception of dengue, age group from 20 to 39 years old prevant in the diseases dengue, TL

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and VL, tuberculosis and leprosy a higher percentage was identified between 40 and 59 years old; brown individuals were more affected in all diseases; and people with high school education recorded a higher occurrence of dengue and those with elementary school the other diseases.

The Capim Dourado region had a high incidence rate of dengue and leprosy, which may indicate a higher risk of illness in this population. The high incidence of leprosy in this region may be linked to population density, considering that leprosy is transmitted by personal contact, but there is a need for this to be prolonged, as this disease has low transmissibility. Having the knowledge of families with an infected member is relevant to stop transmission. As for dengue, it should be considered that transmission is by vector, therefore, the climate in the state with high temperatures, low humidity may be related to the high incidence and prevalence of dengue cases and the occurrence of Leishmaniasis, which may show a tendency to increase. Epidemiological Surveillance must be attentive to environmental issues and epidemic peaks of diseases due to the increase in foci of vector mosquitoes.

The prevention of these diseases involves public health interventions, vector control, improvement in basic sanitation, and health education for the population. This study allowed us to identify the profile of vulnerable and priority health regions at risk of becoming ill. From the analysis of the spatio-temporal evolution of the NTDs prevalent in the state of Tocantins in an integrated and regionalized way, it will be possible to propose to the State Health Department a more effective direction of health actions and services specifically aimed at neglected diseases (dengue, leprosy, visceral leishmaniasis, tegumentary leishmaniasis and tuberculosis). In this context, it is necessary to integrate the indicators of Epidemiological Surveillance in Primary Care, especially in the Previne Brasil Program, for the state of Tocantins, in order to reduce the incidence of these diseases. With the NTDs included in this Program, the municipalities would have goals to achieve to reduce the occurrence of these diseases and consequently released funds that would help in monitoring, combat and prevention strategies.

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