Ciências Agrárias
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Canine atopic dermatitis and its socioeconomic, environmental and public policy risk factors in Belém do Pará, Eastern Amazon, Brazil: a cross-sectional and ecological study

A dermatite atópica canina e seus fatores de risco socioeconômicos, ambientais e de políticas públicas em Belém do Pará, Amazônia Oriental, Brasil: um estudo transversal e ecológico

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Highlights

Non-homogeneous spatial distribution of canine atopic dermatitis in Belém, Pará.
Cases clusters presence in the municipality peripheral and central neighborhoods.
Multifactorial and geographically localized relationship of the disease.
Prioritization of access to animal health services based on case severity.

Abstract

Canine atopic dermatitis consists of inflammatory, pruritic skin lesions caused by bacterial infections, resulting in increased immunoglobulin E levels, and related to the animals' dietary habits. In Brazil, this

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condition is a serious animal health problem due to the socioeconomic, environmental, and health policy factors associated with its occurrence. Therefore, this cross-sectional, ecological study analyzed the spatial distribution of the disease seen at a public veterinary service and its relationship with these factors in Belém, Pará, Brazil, from 2021 to 2023. Data from the Prof. Mário Dias Teixeira Veterinary Hospital, the Brazilian Institute of Geography and Statistics, and the National Institute of Meteorology were used, processed using descriptive, inferential, and spatial statistical techniques. Most records were recorded in females up to 5 years of age, of mixed breed, and in the first quarter of each year during the study period. The location of cases by neighborhood was not homogeneous across the municipality, with clusters associated with high rainfall, a high human development index, and short distances to care in the Guamá, Marco, and Pedreira neighborhoods. The epidemiological profile produced followed the national trend. Regarding territorialization, a hierarchy of access to care institutions was observed, based on the route and time taken. However, the combination of vulnerabilities identified pointed to epidemiological silence in the periphery of the study area. This fact poses a major challenge for dermatitis surveillance, given the persistence of its risk factors. The technologies employed were satisfactory for the study, demonstrating the need for increased care for animal health diseases..

Key words: Epidemiology. Geoprocessing. Dermatophagoides farina. Allergens.

Resumo

A dermatite atópica canina são lesões cutâneas, inflamatórias e pruriginosas, derivadas de infecções bacterianas implicando no aumento da Imunoglobulina E, e relacionadas aos hábitos alimentares dos animais. No Brasil, esta doença é um grave problema de saúde animal, devido as características socioeconômicas, ambientais e de políticas sanitárias associadas à sua ocorrência. Assim, este trabalho transversal e ecológico analisou a distribuição espacial da dermatite estudada atendida em um serviço veterinário público e sua relação com essas condicionantes, em Belém do Pará, Brasil, de 2021 a 2023. Para tal, foram usados dados do Hospital Veterinário Prof. Mário Dias Teixeira, do Instituto Brasileiro de Geografia e Estatística e do Instituto Nacional de Meteorologia, processados com técnicas estatísticas descritivas e inferenciais, além de espaciais. A maioria dos registros foi verificada em fêmeas, com até 5 anos de idade, sem raça definida e no primeiro trimestre de todos os anos do período. A localização dos casos por bairro não foi homogênea no município, com uma formação de aglomerados associados com alta pluviosidade, alto índice de desenvolvimento humano e baixa distância do local de atendimento, nos bairros do Guamá, Marco e Pedreira. O perfil epidemiológico produzido acompanhou a tendência nacional. Já com relação a sua territorialização foi observada a existência de uma hierarquização do acesso às instituições de assistência, baseada no percurso e no seu tempo de execução. Contudo, a conjunção das vulnerabilidades identificadas apontou para um silêncio epidemiológico na periferia da área de estudo. Este fato se constitui de um grande desafio para a vigilância da dermatite, considerando o contexto de manutenção dos seus fatores de risco. As tecnologias empregadas foram satisfatórias para a realização do trabalho, mostrando a necessidade do aumento da assistência às doenças em saúde animal.

Palavras-chave: Epidemiologia. Geoprocessamento. Alérgenos. Dermatophagoides farinae.

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Introduction

Canine atopic dermatitis (CAD) is a pruritic, inflammatory skin condition with a genetic predisposition and clinical manifestations associated with Immunoglobulin E (IgE) antibodies directed against pathogenic mites such as Dermatophagoides farinae, commonly found in the environment (Zanon et al., 2008; Hensel et al., 2023). It has a high prevalence in dogs. The manifestation of this disease may also be associated with secondary bacterial infections and dietary habits (Chrobak-Chmiel et al., 2023). Some studies indicate that the onset of CAD occurs mainly in female Shih Tzu dogs between six months and three years of age (Silva et al., 2024).

In general, epidemiological data related to CAD are scarce worldwide, particularly in Brazil (Ferreira et al., 2023). However, recent studies show that approximately 15% of the global canine population presents this disease, with a non-homogeneous spatial distribution (Kovač et al., 2024). This epidemiological gap constitutes a risk factor for the occurrence and persistence of this dermatitis, especially in the Brazilian Amazon region. In this context, the state of Pará shows a lack of technical and scientific studies on the occurrence of CAD, although reports of cases in its capital, Belém, have been available since 2019 (Calesso et al., 2021).

CAD may be influenced by multiple factors related to socioeconomic conditions (income, education, and housing), which characterize the quality of life of humans cohabiting with animals, as well as by environmental variables (temperature, humidity, rainfall, and wind) that vary seasonally and geographically, similar to other diseases (Miranda et al., 2025; Gonçalves et al., 2025). In this way, the prevalence of CAD tends to increase during certain seasons, such as winter or the rainy season, due to the greater presence of airborne allergens (dust, pollen, and mites). This dermatitis may also be related to the weakness of public health policies in the country, such as the limited availability of animal health surveillance services (Hensel et al., 2023; Pierce et al., 2024).

The municipality of Belém covers an area of 1,059.466 km2, has a humid tropical climate, with an average annual rainfall of 182.42 mm and a mean temperature of 27.03 °C. It has 1,381,475 inhabitants in the urban area and 11,924 in the rural area, distributed across its mainland territory in 52 neighborhoods, of which eight are located in the city center (Batista Campos, Campina, Cidade Velha, Nazaré, Reduto, São Brás, Marco, and Umarizal) and the remainder in peripheral areas (Instituto Brasileiro de Geografia e Estatística [IBGE], 2022). Regarding animal health institutions, the municipality has the Prof. Mário Dias Teixeira HOVET public veterinary hospital (a teaching hospital affiliated with the Federal Rural University of the Amazon), as well as the Dr. Vahia Hospital and the Zoonosis Control Center (CCZ), operated by the Municipal Health Secretariat (SESMA).

In this context, given the high canine population density (approximately 317,666 animals) and the diversity of breeds, studying the spatial distribution of CAD in the municipality poses an epidemiological challenge. It requires the development

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of geographical occurrence scenarios to support sanitary decision-making, especially within the One Health framework. This scenario becomes even more complex when considering environmental factors such as climate (rainfall volume), socioeconomic factors such as the neighborhood Human Development Index (HDI, a variable composed of life expectancy, education, and income that reflects living conditions in territories) and public animal health policies such as the presence of veterinary services (laboratory and treatment facilities).

As a potential technological solution, geoprocessing techniques for obtaining, processing, and analyzing spatial data has been applied to test etiological hypotheses related to disease occurrence and associated risk factors (Gonçalves et al., 2021; Ministério da Saúde [MS], 2023). In this context, Geographic Information Systems (GIS) enable the image-based identification of disease distribution patterns across territories, providing valuable information for epidemiological surveillance and decision-making (Gonçalves et al., 2024). Based on the above, this study analyzed the spatial distribution of canine atopic dermatitis cases treated at a public veterinary hospital and its relationship with environmental, socioeconomic, and public health policy variables in the municipality of Belém, state of Pará, Brazil, from 2021 to 2023.

Materials and Methods

This cross-sectional and ecological study included a population of 203 dogs diagnosed with atopic dermatitis in the municipality of Belém, Pará, from 2021 to 2023. Epidemiological data (sex, age, breed, neighborhood of residence, and trimester) were obtained from the HOVET veterinary hospital database. Diagnoses were based on clinical history, allergen tests, pruritus scale, and identification of characteristic lesions, excluding other dermatoses with similar presentations. Socioeconomic data, including estimated HDI, population by neighborhood, and territorial boundaries, were collected from the 2020 census of the IBGE (2022). Environmental data related to rainfall were obtained from the National Institute of Meteorology (INMET).

The epidemiological, environmental, and socioeconomic databases were cleaned to exclude incomplete, inconsistent, or duplicate case records, as well as records from other municipalities. Data for these variables were processed by trimesters using arithmetic means for the three study years, except for the socioeconomic data. Subsequently, all data were georeferenced in a laboratory to create the Geographic Database (BDGEO). The software TabWin 4.15 and ArcGIS 10.5.1 were used for this process.

Epidemiological profile variables were analyzed descriptively using percentage calculations and inferentially using the nonparametric "chi-square test of expected equal proportions", with a significance level of $p < 0.05$. Average rainfall was estimated using inverse distance weighting (IDW) interpolation. The canine population by neighborhood was estimated using a ratio of 4.25 humans per dog (Junqueira & Galera, 2019). Disease prevalence was calculated using the formula: Prevalence = (number of CAD cases / estimated dog population) × 10,000. The software BioEstat 5.0 and EpiInfo 7.2.5 were used for these calculations.

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The HDI of the neighborhoods was analyzed using the quantile division technique with five intervals: very low (0.573-0.640), low (0.641-0.677), moderate (0.678-0.727), high (0.728-0.790), and very high (0.791-0.927), represented in red, orange, yellow, green, and blue, respectively. The distance (in kilometers, considering route and access time) from the cases' residences to health institutions and services was classified into five gradients: very low (1.990-4.310), low (4.311-6.300), moderate (6.301-8.150), high (8.151-12.710), and very high (12.711-23.410), represented by the colors listed above, respectively.

Subsequently, the prevalence of the disease was classified into four intervals: absent (0), low (0.01-1.89), moderate (1.90-4.46), and high (4.47–18.04), represented by the colors blue, green, yellow, and red, respectively. The density of disease cases was determined using the Kernel technique, which considered the following gradient: very low (0-12,106), low (12,107-39,111), moderate (39,112-77,291), high (77,292-138,751), and very high (138,752-237,461), represented by the colors dark green, light green, yellow, orange, and red, respectively. All spatial analyses described above were performed using ArcGIS 10.5.1 software.

To assess the statistical significance of the spatial relationship between the occurrence of the disease and its predictor variables (HDI, estimated dog population, and distance from the cases' residences to the animal health service), the spatial multiple regression technique based on the least squares method was applied using GeoDa 1.22 software. This study was approved under no. 8768210622 by the Ethics Committee on the Use of Animals (CEUA) of the Federal Rural University of the Amazon (UFRA).

Results

A total of 203 cases of canine atopic dermatitis were analyzed, showing a non-homogeneous distribution across the neighborhoods of Belém between 2021 and 2023. The analysis of the epidemiological profile revealed a higher percentage of cases among females (63.05%), animals under five years of age (52.71%), and mixed-breed dogs (46.80%), with most occurrences recorded in the first trimester (40.39%). Among the known breeds, the highest prevalence of dermatitis was observed in Shih Tzus (20.69%) and Poodles (16.26%). All variables showed statistical significance ($p < 0.05$), as shown in Table 1.

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Table 1
Epidemiological and clinical profile of canine atopic dermatitis cases treated at the Prof. Mário Dias Teixeira Veterinary Hospital/Federal Rural University of the Amazon, Belém, Pará, from 2021 to 2023

Variable	Category	n = 203	%	p-Value
Gender	**F**	**128**	**63.05**	0.0002
	M	75	36.95	
Age group (years)	**Up to 5**	**107**	**52.71**	< 0.0001
	6-11	80	39.40	
	12-14	14	6.90	
	Not informed	2	0.99	
Breed	**SRD**	**95**	**46.80**	< 0.0001
	Shih-tzu	42	20.69	
	Poodle	33	16.26	
	Dachshund	21	10.34	
	Not informed	12	5.91	
Trimester	**1**	**82**	**40.39**	< 0.0001
	2	70	34.48	
	3	29	14.29	
	4	22	10.84	

Source: Research protocol, 2025.

The spatial analysis of CAD prevalence indicated a non-homogeneous distribution of this indicator within the study area and period. High prevalences, associated with a greater number of cases relative to the estimated dog population, were observed in the Val-de-Cães and Curió-Utinga neighborhoods. Moderate prevalences occurred in Guamá and Cremação, low in Tapanã and Jurunas, and absence in Águas Negras and Universitário. This pattern was recurrent throughout the study period, especially in the peripheral neighborhoods, in contrast to the central ones, as shown in Figure 1.

The analysis of the spatial and temporal distribution of average rainfall and CAD prevalence across neighborhoods indicated a possible seasonal trend in this association. In this regard, peripheral areas showed higher rainfall volumes compared to central areas. Accordingly, a high rainfall volume and a high disease prevalence were identified during the first trimester of the study, mainly in the Marco and Pedreira neighborhoods. Nonetheless, low or absent values of both variables were observed in the last three months of the series, particularly in Pratinha and Benguí (Figure 1).
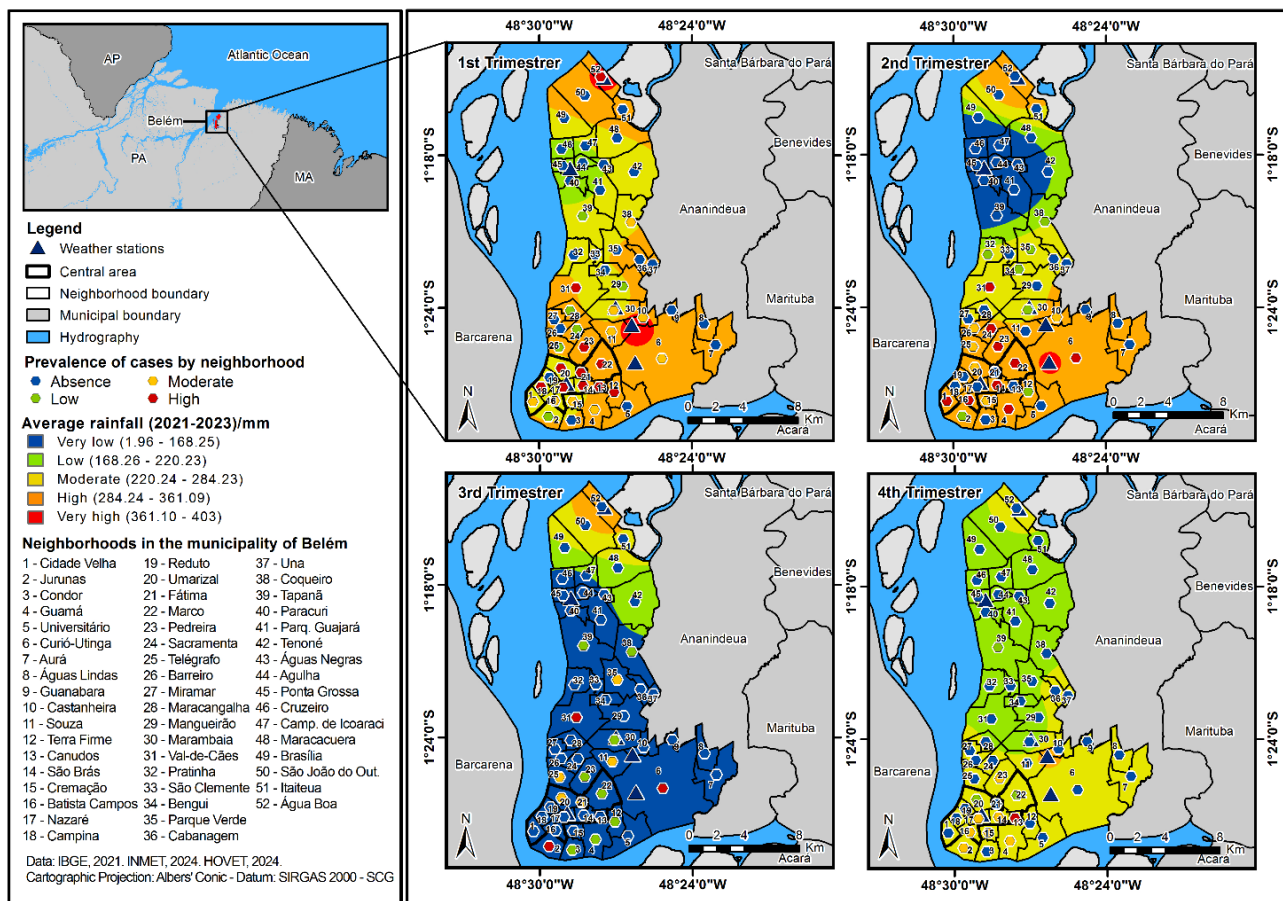
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Figure 1. Prevalence of canine atopic dermatitis and rainfall by trimester in Belém, Pará, during the period from 2021 to 2023.

Kernel density analysis revealed clusters of cases within the study area, with high and very high densities in central neighborhoods such as Umarizal and Marco, and in peripheral ones such as Guamá and Pedreira. Furthermore, based on rainfall distribution, a possible spatial persistence of clusters was identified in Pedreira and Guamá. Considerable spatial variability was observed in the relationship between CAD density and the Human Development Index (HDI). Neighborhoods with high or very high HDI showed high or very high case numbers, such as Pedreira and Guamá, while those with low or moderate socioeconomic levels, such as Val-de-Cães and Terra Firme, displayed moderate or high disease rates (Figure 2).

Additionally, areas with high or very high distances from the veterinary hospital (HOVET) showed low disease occurrence, such as Água Boa and Pratinha. Conversely, areas located at very low or short distances exhibited high or very high case densities, such as Pedreira and Guamá. The spatial multiple regression analysis demonstrated a spatial dependence between the variable "prevalence of CAD" (y) and its determinants

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"HDI" (x_1), "estimated number of dogs" (x_2), and "distance from the cases' residences to the health service" (x_3), expressed by the equation $y = -7.0550 + 11.7861x_1 + 0.0008x_2 - 0.0251x_3$, with $R^2 = 0.651351$ and an F-statistic of 28.0047, showing spatial statistical significance for $p < 0.0001$ (Figure 2).
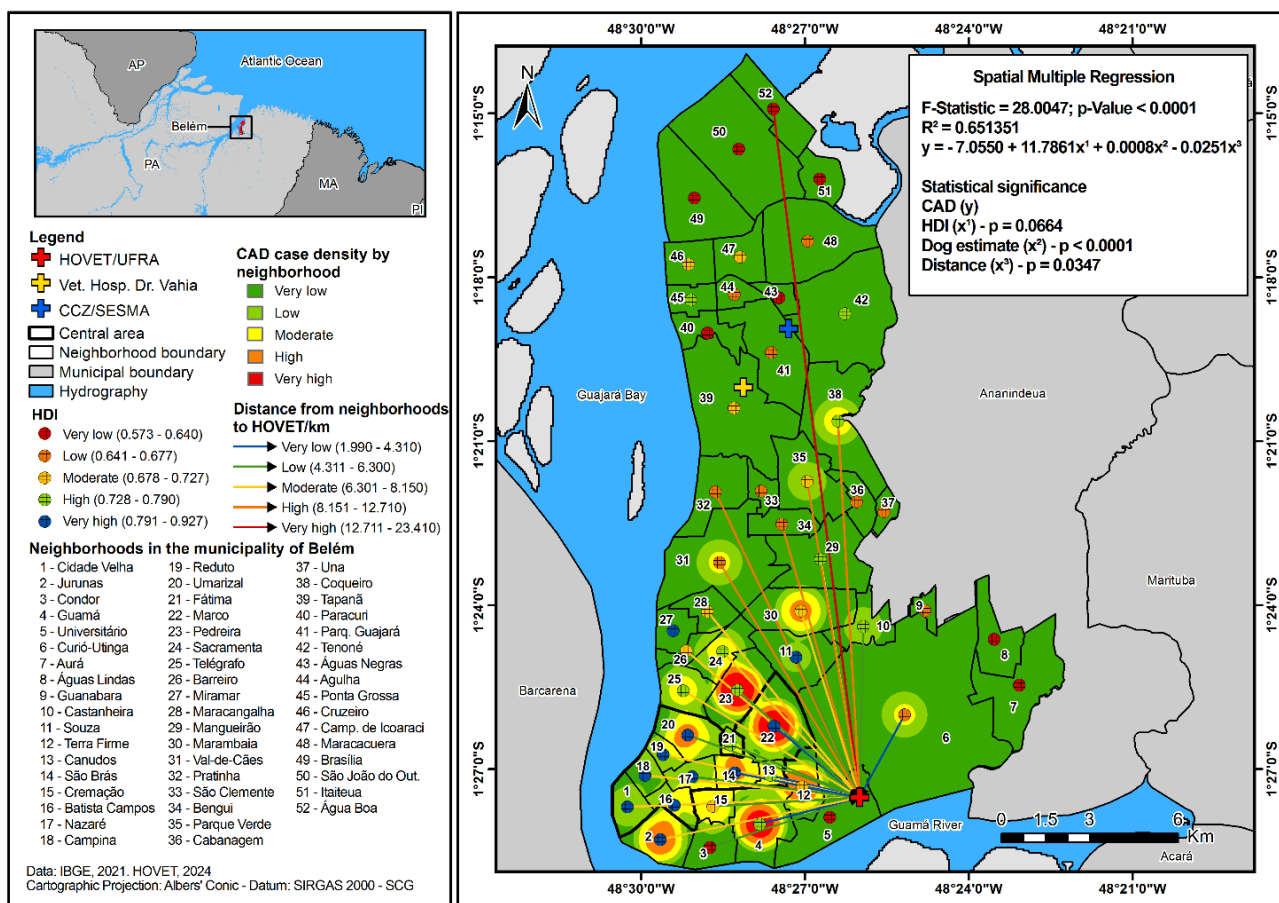

Figure 2. Density of canine atopic dermatitis cases, Human Development Index (HDI), and location of animal health institutions in Belém, Pará state, during the period from 2021 to 2023.

Discussion

The higher percentage of canine atopic dermatitis (CAD) in females (63.05%) may be attributed to a genetic predisposition for this sex (Hensel et al., 2023; Dong et al., 2024). The high occurrence of dermatitis in animals under five years of age is likely associated with behavioral factors in adult dogs, such as licking and biting during socialization and reproduction outside the home, which constitute risk factors for the disease (Morales-Romero et al., 2025). The greater occurrence of atopic dermatitis in

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mixed-breed dogs may be related to the large number of people adopting stray animals, most of which do not have a defined breed (Roque et al., 2024).

The higher incidence of the disease in Shih Tzus and Poodles can be explained by a deficiency in their skin barrier, resulting from genetic predisposition, which leads to immune system sensitization and increased IgE production (Couceiro et al., 2021; Ferreira et al., 2023). The fact that the highest number of atopic dermatitis cases occurred in the first trimester of all years in the study period suggests a possible seasonal dimension of the disease. This pattern may be associated with the environmental characteristics of the affected locations. Climatic variables such as humidity and rainfall may act as conditioning factors for this disease, given the evidence of associations between climate and various allergic and infectious processes reported in studies conducted in several parts of the world (Marsella, 2021; Grafanaki et al., 2023; Widorn et al., 2024; Dong et al., 2024).

The non-homogeneous spatial distribution of CAD in Belém reflects the multifactorial nature of this disease. Therefore, the higher prevalence observed in certain neighborhoods is likely related to their large estimated dog populations, as in Curió-Utinga, Jurunas, and Val-de-Cães. Moreover, the simultaneous occurrence of higher rainfall and higher CAD prevalence, and of lower rainfall and lower prevalence (respectively in the first and fourth trimesters of the study period) can be explained by the heterogeneous climatic characteristics of Belém, such as differences in rainfall intensity across neighborhoods. This phenomenon favors the release of allergenic particles, especially in areas with a higher concentration of vegetation, as these particles are attracted to water droplets and subsequently dispersed via air (Brake et al., 2023).

Thus, the epidemiological scenario of CAD in the municipality of Belém likely reflects an environmental production context, possibly influenced by aerosols occurring on a microscale in the atmosphere and the formation of cumulonimbus clouds over some neighborhoods, resulting in differentiated rainfall regimes. Therefore, the observed spatial relationship between rainfall and disease prevalence, statistically significant in the multiple spatial regression, aligns with studies on this topic, including those investigating other infectious diseases in Brazil (Miranda et al., 2022; Gonçalves et al., 2023). This observation serves as evidence of a potential future animal health problem, considering changes in rainfall patterns in the study area driven by anthropogenic factors such as deforestation in the Amazon (Leite et al., 2021; Lobato et al., 2024).

The territorial analysis of living conditions in Belém, assessed through the Human Development Index (HDI) and its relationship with CAD case density, revealed a direct association between these two variables, with statistical spatial significance in the regression analysis. This fact can be explained by income concentration, which is very high in certain central neighborhoods of the municipality that also presented a higher number of cases, particularly among Poodle and Shih Tzu dogs, whose treatment is considered costly. Conversely, peripheral neighborhoods characterized by low or very low economic conditions and lower-

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case densities may reflect limited financial resources and transportation infrastructure, which hinder access to the veterinary services offered by HOVET. This hierarchical form of access to animal health institutions indicates the need for spatial decentralization of these services.

This situation is further aggravated by the greater distances between the residences in these peripheral areas and the public animal health facilities, compared to those located nearby. The simultaneous occurrence of epidemiological, environmental, and socioeconomic variables and the distance from the veterinary hospital as conditioning factors of CAD in the municipality of Belém points to a spatial dependence among these factors. This relationship results in the systematic production of risk conditions for the establishment of the disease, including the potential existence of silent areas of occurrence. Such an adverse scenario constitutes a major public health issue marked by inequities in access to diagnostic and treatment services for the studied dermatitis.

Conclusion

This study analyzed the spatial distribution of CAD in dogs treated at a public veterinary hospital in Belém, Pará. The results revealed an epidemiological profile characterized by a higher occurrence in females, animals up to five years of age, mixed breeds, and during the first trimester. The findings also showed that this dermatitis is multifactorial, as evidenced by its non-homogeneous distribution and the presence of case clusters in areas with high rainfall, high HDI, and short distances from animal health services. These results point to a possible epidemiological silence associated with socioeconomic inequities, highlighting the need for ongoing studies. Given these findings, the statistical and spatial analysis techniques used were effective in constructing the disease's epidemiological scenario, confirming its relevance as a major public health concern in the municipality. Therefore, it is essential to expand animal health care institutions focused on CAD, with a particular emphasis on decentralizing services in areas characterized by epidemiological and socioeconomic vulnerability.

Acknowledgments

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