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Increasing Incidence of Bee Stinging in Brazil: An Epidemiological Study

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Background and Aim: Latin America is home of the highest biodiversity of venomous species globally. In Brazil, envenomation incidents are the second leading cause of human intoxications, surpassed only by medication-related events. Envenomation represents a significant public health issue due to their high incidence and potential lethality, classifying them as one of the major

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neglected tropical diseases. Among venomous animals, bees, particularly those of the genus *Apis*, are responsible for a considerable number of incidents. Bee stings can induce severe adverse reactions, including anaphylaxis, which can be fatal if not promptly treated. This study aims to describe the epidemiological profile of bee sting incidents in Brazil based on data from the national Notifiable Diseases Information System (SINAN).

Methods: A descriptive and retrospective epidemiological analysis was conducted on bee sting cases registered in the Notifiable Diseases Information System (SINAN) in Brazil from 2013 to 2023. The data were categorized by region, gender, ethnic self-identification, work-related incidents, and classification of the severity. This information was compiled into electronic spreadsheets and statistically analyzed to identify trends and epidemiological patterns.

Results: A total of 206,656 cases of bee sting were recorded between 2013 and 2023, with an annual average of 18,074 cases. An increase in the incidence of bee stings was observed over the years, with over 30,000 cases in 2023. Most accidents were recorded in the Southeast, Northeast, and South regions, where there is a higher concentration of apiaries. Although the number of bee sting cases has consistently increased over the last decade, mortality rates have fluctuated between 0.0034% and 0.0022%, showing no statistically consistent trend. The analysis showed that most cases occurred among men, reflecting the predominance of males in outdoor activities and beekeeping. Anaphylaxis was the main cause of deaths, with a low but significant mortality rate.

Conclusion: The analysis of the recorded data highlights the need for specific public health strategies to prevent and treat bee sting incidents. Implementing standardized clinical protocols and improving access to prompt medical care in rural and remote areas are essential to reducing the lethality associated with these incidents. Raising awareness and educating the public about the risks and preventive measures are crucial to minimizing the impact of bee stings. Additionally, studies on regional peculiarities are necessary to determine the epidemiological risks and inform the public health measures required to minimize such events.

Keywords: Apis mellifera; bee stings; venomous animals; epidemiology, Brazil.

1. INTRODUCTION

Latin America harbors one of the highest biodiversity of venomous species, causing accidents [1]. In Brazil, accidents involving venomous animals are considered the second leading cause of human intoxication, surpassed only by medications [2]. Envenomation is considered a serious public health issue because of the high occurrence rate and the potential for lethality [3,4], and are classified as one of the major neglected tropical diseases [5,6,7].

Venomous animals own specific anatomical structures to inject biologically active compounds produced by specialized glands into other animals, primarily used for predation and defense [8]. In the case of bees, apitoxin is injected through a specialized stinging apparatus located at the end of the abdomen. During the bee's defensive act, the stinger penetrates the target's skin, and the apitoxin is released from a storage sac connected to the stinger [9].

Insects of the order Hymenoptera are responsible for many stinging incidents involving humans. Most of these events are caused by bees, primarily of the genus *Apis* [10,11,12,13,14]. The venom of *Apis* genus bees contains a diversity of substances that are clinically significant in human incidents, with different biological actions and potential adverse effects, mainly allergic reactions. The main components of *Apis* spp. venom are melittin and phospholipase A2, which together constitute about 75% of the venom's composition and are the most studied for their biological effects [8,15,16]. Melittin is a substance that engage with human erythrocyte membranes inducing erythrocyte breakdown, while phospholipase A2 is a recognized allergen that may result in respiratory paralysis and acts as the primary allergenic factor in humans. Additional constituents encompass apamin, which functions as a neuronal toxin with the capability to induce cardiac arrhythmias, and mast cell degranulating peptide, which stimulates the liberation of histamine and serotonin, contributing to inflammatory responses and discomfort sensations. The poison of this bee genus also encompasses enzymes such as hyaluronidase, which facilitates the dissemination of the poison across tissues, and various amines, like histamine and epinephrine, which perform diverse functions in allergic reactions and inflammatory processes [8,15,17]. Clinically, the impact of this kind of venom can range from mild

localized inflammation to severe systemic consequences, including anaphylaxis, that can be fatal if not promptly managed [16,18,19,20]. Anaphylactic shock accounts for half of the fatal cases from bee stings [21]. The most frequent severe clinical condition, aside from anaphylaxis, is acute kidney injury, usually resulting from rhabdomyolysis and intravascular hemolysis, with renal tubule obstruction or direct cytotoxic injury [22,23,24]. Systemic dysfunctions involving multiple organs present a complicated and poor prognosis clinical picture, severely compromising the life of individuals who suffered multiple bee stings [25,26]. The absence of cutaneous symptoms is a predictor of severe systemic reactions [27,28]. In cases of massive bee attacks, especially hybrids of various species of the *Apis* genus, the risk of severe reactions and fatalities increases, necessitating rapid medical intervention to neutralize the action of the toxins and immune responses with severe side effects [26,29,30].

The growing incidence of accidents involving venomous animals is attributed mainly to new dynamics on urban mobility and rural areas, where increased human contact with nature affects the ecosystem, forcing these animals to migrate to other suitable locations for their development, such as residences, vacant lots, and constructions [31]. Additionally, recent climate changes, increased rainfall indices, deforestation, and significant environmental changes alter the distribution, behavior, and degree of interaction between bees and humans, leading to a higher incidence [32,33,34]. Bees are ectothermic insects, whose activity varies depending on ambient temperature. As temperatures rise, bees may become more active and aggressive, increasing the likelihood of contact with humans and, consequently, the possibility of stings [35]. There are also individual risk factors related to human behavior and occupational activities. Individuals with low educational levels, who engage in outdoor labor or recreational activities, or who do not observe safety conditions in handling bees are more susceptible to stinging by these insects [1,6,31].

The epidemiology of bee stings is influenced by regional factors, with varying incidence rates, demographic profiles, and clinical outcomes, requiring customized public health strategies and medical responses in different parts of the world. The aim of this study is to describe the epidemiological profile of bee stings in Brazil based on the Notifiable Diseases Information System (SINAN), which integrates the database of the Department of Information and Informatics of the Unified Health System (DATASUS) in Brazil.

2. METHODS

This study has a descriptive and retrospective design of epidemiological analysis of bee sting cases recorded by the Notifiable Diseases Information System (SINAN). SINAN is a computerized system used in Brazil to register and monitor cases of diseases and conditions that are mandatory for notification. This system catalogs data on the incidence and distribution of these conditions, assisting in epidemiological surveillance and the planning of public health actions.

The cataloging and consolidation of the results obtained from the SINAN database considered the total number of confirmed cases and deaths across the entire Brazilian territory, divided according to its five regions, with a time frame from 2013 to 2023. The data were grouped for analysis in Microsoft Excel spreadsheets according to the following variables: gender, ethnic self-identification, and work-related accident.

As this research is based on data of a publicly available database that ensures the anonymity of the patients, there is no need for submission to an ethics committee.

3. RESULTS

Bee stings are the only Hymenoptera-related injuries that require mandatory notification in Brazil. During the study period, 206,656 cases of bee sting incidents were identified between January 2013 and December 2023, resulting in an annual average of 18,074 cases. An increasing trend in the incidence of bee sting incidents was observed during this period. In 2023 alone, over 30,000 cases were reported, marking the year with the highest incidence of this type of event (Fig. 1).

4. DISCUSSION

Bee sting incidents were reported in all Brazilian states between 2013 and 2023 (Fig. 2). Bees of the genus *Apis* have a significant capacity for dispersion, and since the introduction of polyhybrids known as “Africanized bees” in São Paulo state in 1956 [36], they have colonized all

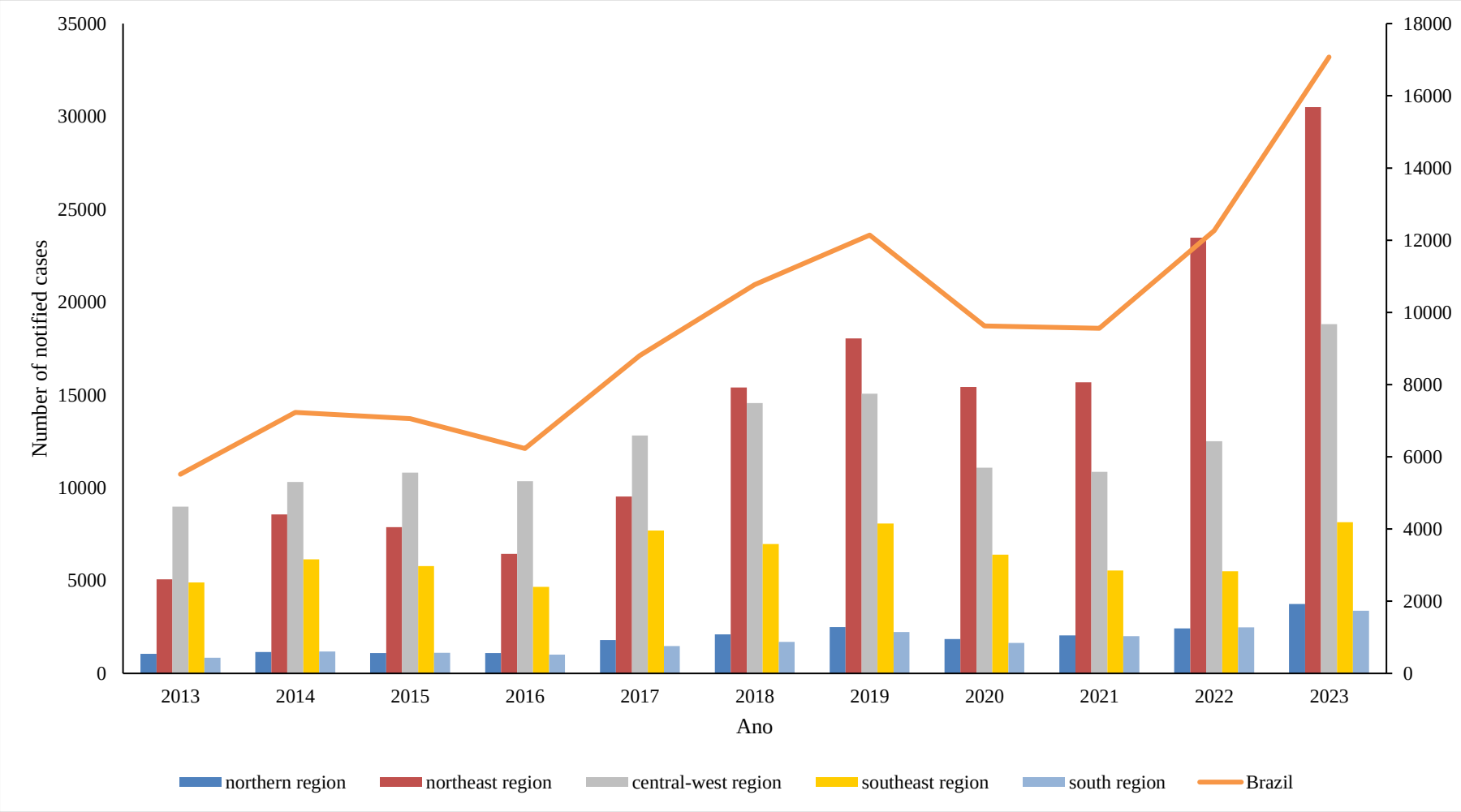

Fig. 1. Total number of cases of bee stings, from January 2013 to December 2023, Brazil

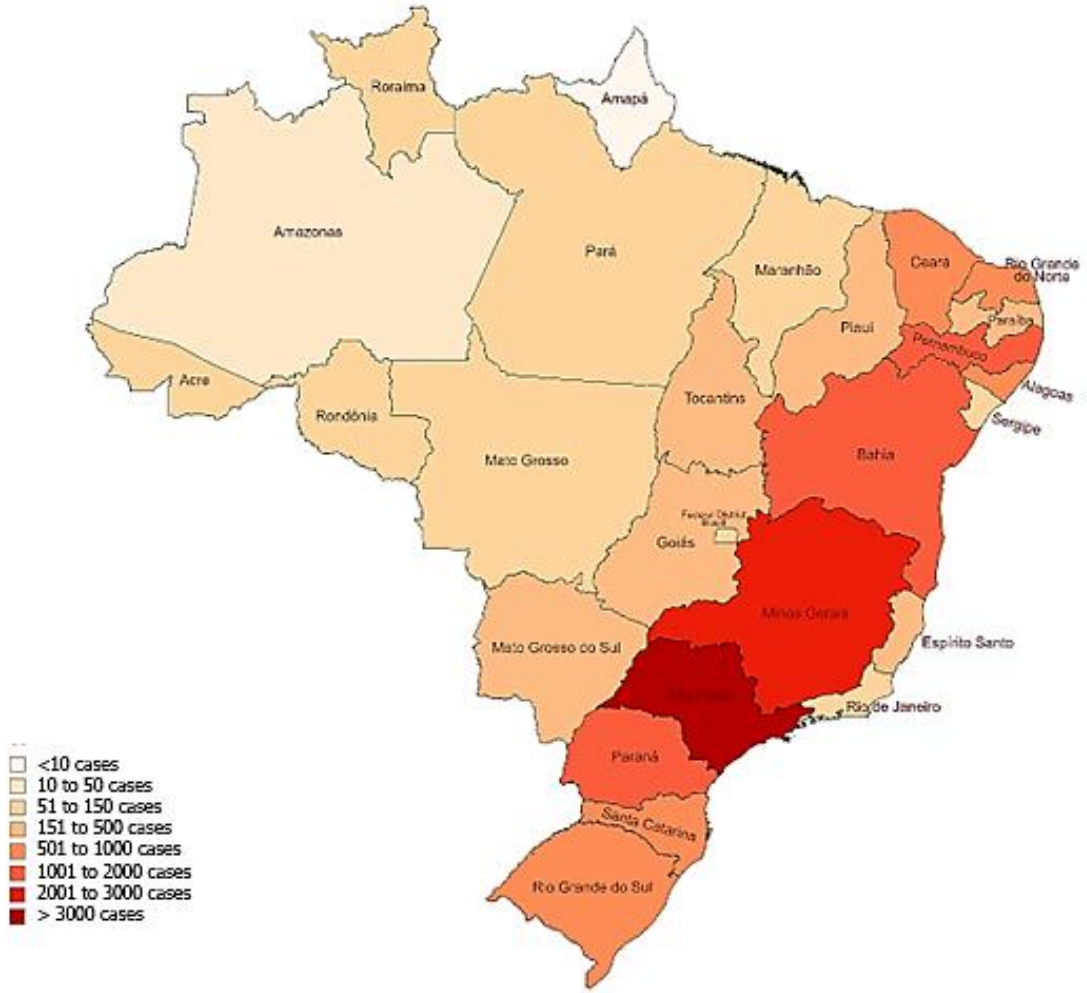

Fig. 2. Geographic distribution and averages of recorded cases of bee stings from January 2013 to December 2023, Brazil

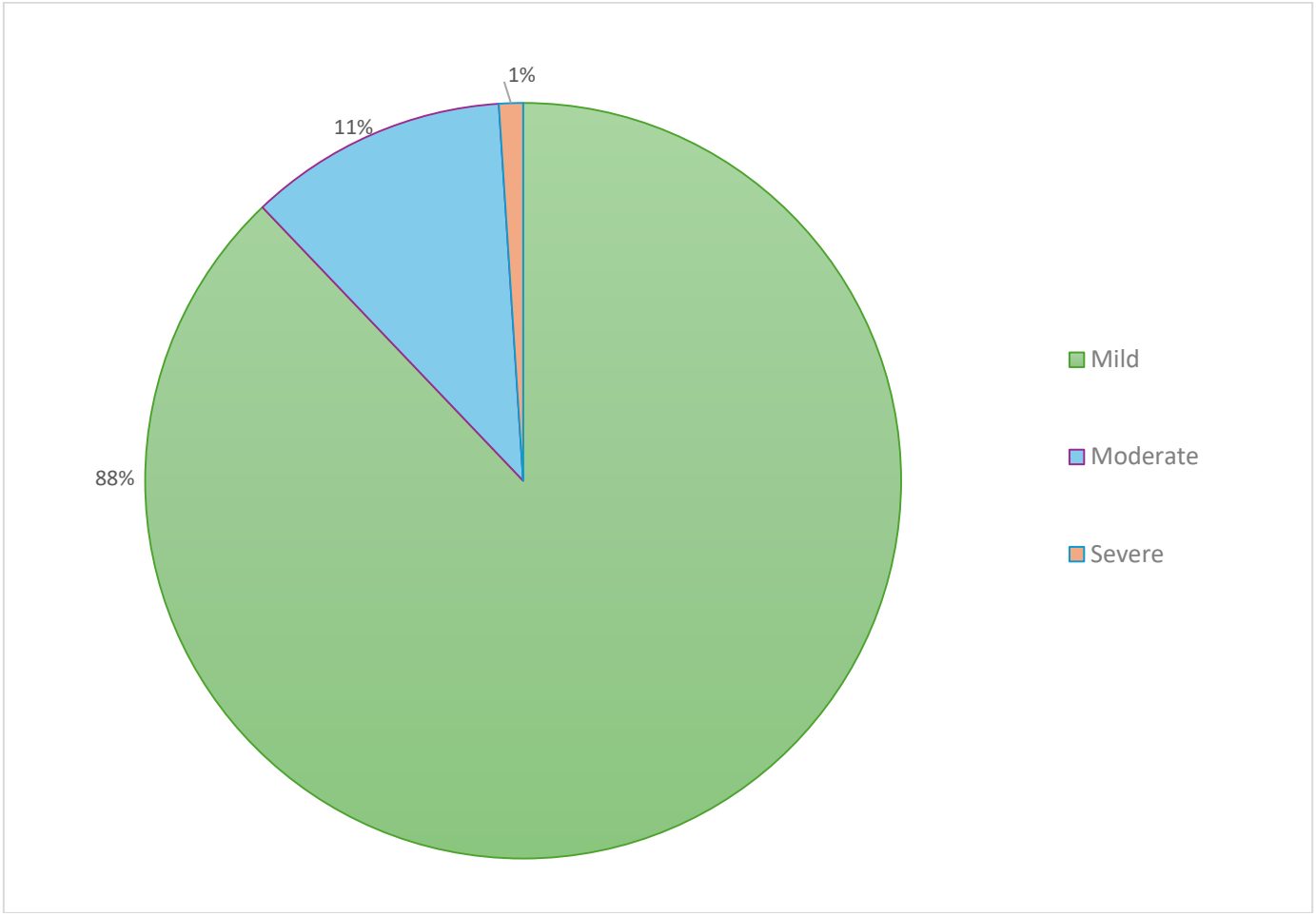

Fig. 3. Classification of the severity of bee stings, from January 2013 to December 2023, Brazil

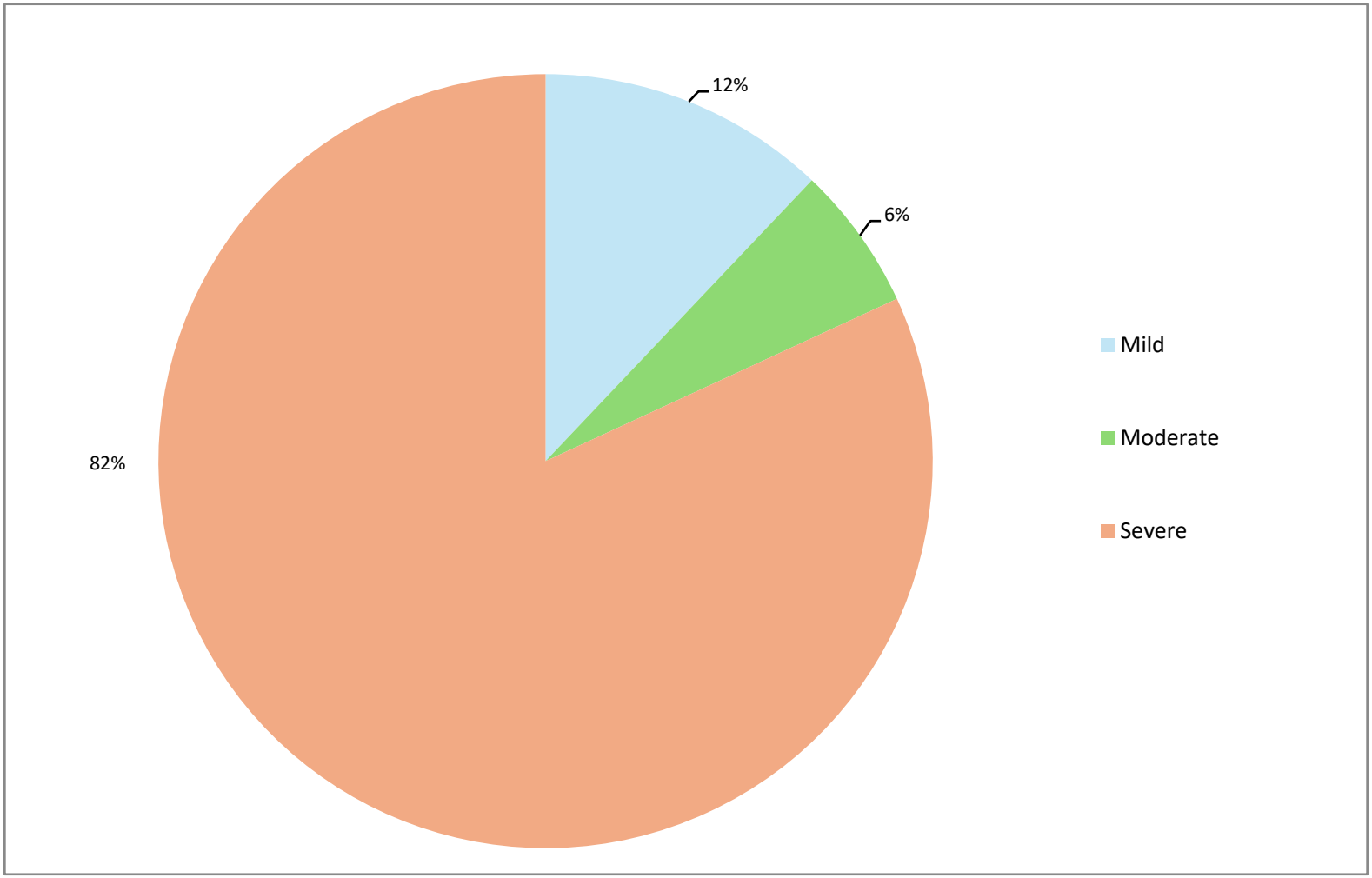

Fig. 4. Deceases associated with severity classification of bee stings, from January 2013 to December 2023, Brazil

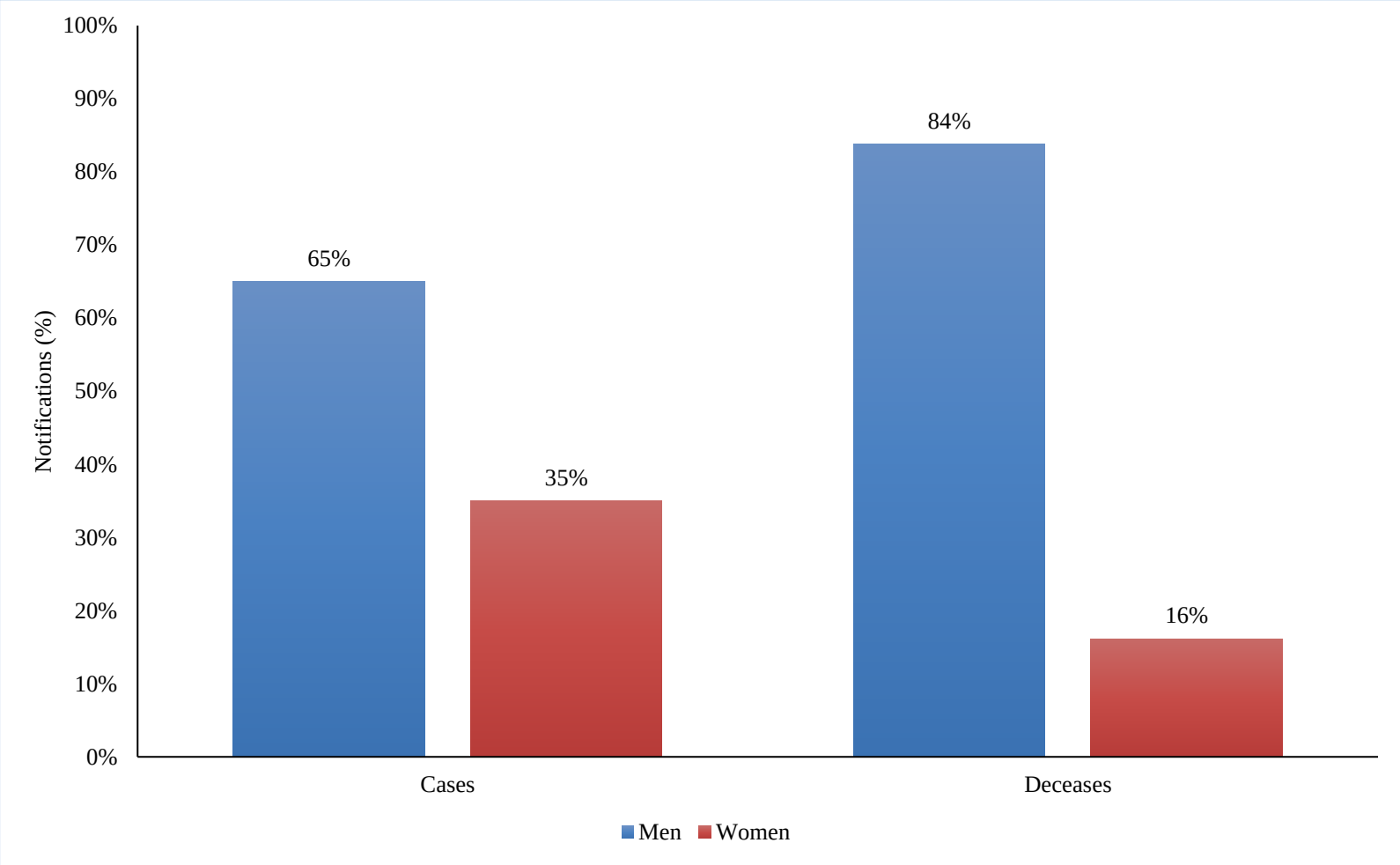

Fig. 5. Cases and deceases consequent to bee stings distributed by gender, from January 2013 to December 2023, Brazil

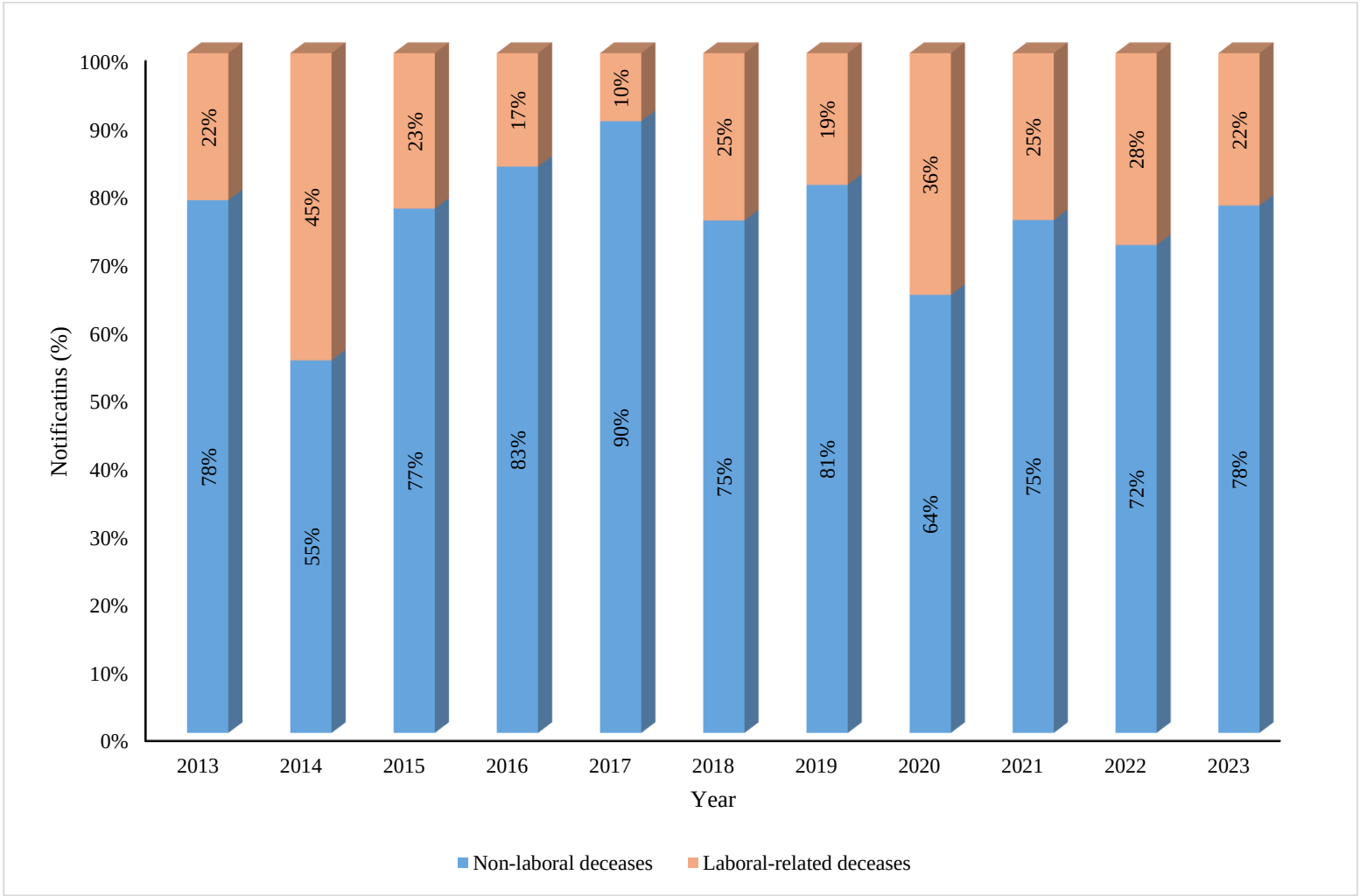

Fig. 6. Distribution of deceases consequent to bee stings according to human activities, from January 2013 to December 2023, Brazil

Table 1. Total number of cases of work accidents and total number of cases of registered bee stings, from January 2013 to December 2023, Brazil

		2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	Overall
Northern region	Total cases	544	594	565	561	924	1079	1285	950	1054	1248	1920	**11165**
	Laboral-related cases	14,70%	12,96%	12,57%	10,52%	9,20%	9,08%	10,82%	12,11%	11,95%	13,38%	11,88%	**11,64%**
Northeast region	Total cases	2606	4403	4051	3310	4898	7917	9277	7931	8064	12068	15686	**82519**
	Laboral-related cases	5,03%	4,57%	4,42%	4,56%	5,45%	5,13%	5,38%	5,13%	4,90%	5,49%	5,03%	**5,13%**
Southeast region	Total cases	4622	5306	5562	5322	6593	7488	7750	5698	5586	6429	9673	**74224**
	Laboral-related cases	15,86%	14,98%	13,66%	13,19%	14,47%	13,76%	14,39%	14,58%	14,95%	14,53%	13,83%	**14,29%**
South region	Total cases	2521	3157	2975	2397	3955	3587	4153	3286	2853	2830	4186	**38620**
	Laboral-related cases	15,27%	13,02%	13,28%	13,10%	13,75%	13,16%	14,21%	15,49%	13,92%	14,56%	15,63%	**14,28%**
Central-west region	Total cases	435	604	572	522	756	872	1147	846	1031	1274	1733	**10357**
	Laboral-related cases	15,40%	12,42%	8,04%	10,54%	12,70%	11,12%	10,99%	11,94%	14,55%	14,36%	13,85%	**12,73%**
Brazil	Total cases	10728	14064	13725	12112	17126	20943	23612	18711	18588	23849	33198	**216885**
	Laboral-related cases	13,01%	11,09%	10,57%	10,58%	11,36%	10,04%	10,46%	10,49%	10,24%	9,89%	9,78%	**10,59%**

Table 2. Distribution of bee stings according to self-declared race/ethnicity, from 2013 to 2023, in Brazil

	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	Total
White	5302	6348	6085	5432	7935	8381	9184	6935	6512	7260	11085	80459
Black	380	493	502	427	640	799	874	800	822	970	1368	8075
Asian	44	73	100	59	106	130	168	126	106	154	204	1270
Pardo (mixed-race)	3170	4706	4523	3978	6187	8963	10844	8710	9012	12764	17473	90330
Indigenous	40	39	53	41	70	78	101	89	102	132	198	943

Table 3. Distribution of bee stings, according to severity and mortality rates in the period 2013 to 2023, in Brazil.

	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	Total
Mild	9059	11974	11662	10186	14380	17693	19770	15432	15083	19347	26916	171502
Moderate	1057	1275	1249	1249	1827	2084	2423	2005	2117	2663	3808	21757
Severe	101	115	114	97	165	182	228	197	180	271	376	2026
Deceases	37	31	35	30	50	61	62	76	53	78	124	637
Mortality rate	0,0034	0,0022	0,0026	0,0025	0,0029	0,0029	0,0026	0,0041	0,0029	0,0033	0,0037	

regions of the country [37,38], exhibiting substantial genetic diversity [39]. This diversity influences swarming behavior and aggressiveness [40,41], potentially affecting the incidence rates of bee sting incidents in different regions. In São Paulo state, over 3,000 cases were reported annually on average, followed by Minas Gerais with approximately 2,300 cases.

The increase in the number of bee sting incidents in Brazil is supported by several regional studies in the states of Ceará [13,42], Rio Grande do Norte [14], Bahia [43], Paraíba [44,45], and Minas Gerais [46]. Other recent researches with nationwide data also confirm the rising trend in bee sting incidents in Brazil over the past decades [47,48,49].

Historically, the Northeast, Southeast, and South regions have the highest concentration of beekeeping farms, also known as apiaries [50], corresponding with the states with the highest incidence of cases. About 10.6% (n = 22,971) of the reported cases were laboral-related, with the Southeast region having the highest rate in the country (14.29%), followed by the South region with 14.28% of work-related cases (Table 1). According to Carli et al. [51], the overall lifetime prevalence of self-reported systemic allergic reactions to bee venom among beekeepers is estimated at 23.7%. The low incidence among beekeepers is attributed to their knowledge of bee behavior, use of personal protective equipment, and adoption of safe hive management strategies, such as wearing protective clothing and using smoke to disorient the bees [43,45,52].

SINAN data do not provide information on the symptomatology of bee sting cases. There is no standardized clinical protocol in Brazil for the treatment of bee stings, and medical care varies according to the severity of the symptoms. The most common treatment includes removing the stinger, applying cold compresses, analgesics, and antihistamines [20,53]. In most reported cases, the consequences were considered mild (μ = 15,591; 88%), where victims experienced inflammatory reactions, as itching, warmth, redness, and hives at the sting site, potentially progressing to nausea, headaches, and abdominal pain (Fig. 3). However, it is noteworthy that about 6 to 12% of deaths resulted from cases initially considered mild or moderate (Fig. 4), possibly due to inadequate medical care in certain regions [20]. The delay in obtaining medical help increases the risk of severe reactions four to eight times if assistance is delayed between 4 and 12 hours, as frequently occurs in remote Amazon regions [54].

Gender analysis shows that more than half of the reported cases involved males (μ = 140,895; 65%). Although the fatality rate is considered low (μ = 0.30%), it is noteworthy that most deaths also follow this trend, with the majority involving males (μ = 49; 84%) (Fig. 5). The predominance of males in bee sting cases can be attributed to a combination of behavioral and occupational factors. Men are more likely to engage in outdoor activities and professions that increase the risk of bee encounters and constitute the majority of the beekeeping workforce [21,37,42,44,48,55].

When analyzing ethnic-racial bee stings incidence, it is essential to highlight the changing in ethnic self-identification over the years (Table 2). Historically, racial classification in Brazil has been fluid, influenced by socioeconomic status and regional demographics [56]. Between 2013 and 2017, the population group with the highest incidence was predominantly recorded as white (μ = 7314; 44.4%). However, in recent years of the temporal analysis, there has been a substantial increase in cases among individuals classified as pardo (mixed race) (μ = 8212; 49.9%) starting from 2018. The increase in individuals who self-identify as pardo in the 2022 census [57] is proportionally consistent with the ethnic-racial distribution observed from 2018 onwards for individuals afflicted by bee stings.

Data on work-related deaths from bee stings indicate that these represent less than half of the notifications (Fig. 6). Although SINAN data do not allow for an in-depth analysis, the primary cause of death from bee stings is anaphylaxis [21]. Most fatalities occur in rural areas where access to medical resources is often limited, delaying the urgent care needed after bee stings and leading to higher mortality rates [54,58]. Brazil's vast territory and the long distances between remote areas and urban centers or healthcare posts hinder patients' rapid access to medical care, increasing the risk of death from bee stings [48]. Although the number of bee sting cases has consistently increased over the last decade, mortality rates have fluctuated between 0.0034% and 0.0022% (Table 3), showing no statistically consistent trend. Another important aspect is that while the overall lethality was low considering the total number of victims (μ = 0.25%), between 5% to 12% of deaths resulted from cases considered mild or moderate. This may be due to the lack of

a specific protocol for this type of incident in Brazil, as well as the absence of objective criteria for risk classification or failure to recognize that stings without cutaneous reactions are a risk for developing severe systemic reactions [27,28], which can appear after the patient is discharged from the health unit, delaying the treatment of severe reactions in a timely manner. Various protocols and methods exist for determining the severity of bee stings, involving a combination of clinical evaluations, molecular diagnostics, and immunological assessments [59,60]. Adopting some of these criteria would help determine the severity, specificity, and urgency of care and potentially reduce mortality rates. Other specific consequences for refining epidemiological data with the adoption of protocols to determine the severity of bee sting cases would be the standardization of severity criteria and increased reliability of SINAN records.

This study had limitations regarding the variables and data available in the Notifiable Diseases Information System, as, in addition to underreporting, there is a possibility of duplicate event entries in the system by different health units, impairing the real analysis of the epidemiological profile of bee sting incidents, leading to an overestimation of cases and improperly increasing the incidence rate. Bochner and Souza [61] point out discrepancies between local records of venomous animal incidents and those in the DATASUS database, which includes SINAN. Nevertheless, the integrity of SINAN notifications has improved over the years, although socio-economic and occupational fields lack information to ensure accurate data recording that supports effective public health policies and actions regarding venomous animal incidents [62]. Furthermore, since 2020, data from Espírito Santo are no longer available in SINAN, being sourced from the e-SUS Information System used by the state. Considering that SINAN is a nationwide database, it constitutes an important tool for analyzing health-related data in Brazil. In this sense, Feás et al. [21] argue that using a broad database based on national records allows for the analysis of temporal trends and age/sex distributions of deaths related to Hymenoptera stings, while regional epidemiological data can indicate particularities for adjusting public health actions locally [21]. Regarding the epidemiology of bee sting incidents, analyzing records serves as a basis for proposing more effective public health policies and actions, particularly in preparing health professionals in areas with a higher incidence of these events and in the efficient supply of antiallergic medications and, in the future, the anti-apitoxin serum currently in the final phase of clinical trials at the Vital Brazil Institute [63,64], in planning logistical distribution to healthcare units with higher demand.

5. CONCLUSION

Insect stings from the order Hymenoptera are common events and represent a serious health risk, impacting human, animal, and environmental health. However, the risk of bee sting incidents is amplified by close coexistence with these insects, and while these incidents are also related to work environments, beekeepers account for less than half of the reported fatalities due to their careful handling of hives. Therefore, it is essential to invest in specific actions and strategies to address this issue, including training healthcare professionals and disseminating information to the public through health education campaigns and informative brochures. These measures are crucial to reducing the number of incidents and ensuring an effective emergency response.

Despite the increasing temporal trend in bee sting incidents, there are few epidemiological studies on this type of injury in the country. Implementing public policies related to these incidents plays a fundamental role in public health by preventing complications and reducing the morbidity and mortality associated with these incidents.

The registration of bee stings incidents in all Brazilian states between 2013 and 2023 indicates that this is a national problem, although incidence rates vary across different regions. The Northeast, Southeast, and South regions, particularly São Paulo and Minas Gerais, have the highest incidence rates. This observation aligns with the fact that these regions have the highest number of apiaries and consequently a larger population of *Apis* bees. The low number of reported incidents among beekeepers may indicate that the use of personal protective equipment and knowledge of bee behavior positively influence the prevention of stings. The higher incidence of incidents among males is consistent with other epidemiological studies and is explained by behavioral and occupational characteristics.

The lack of a standardized clinical protocol for the treatment and assessment of the severity

and risks associated with bee stings is a challenge to be overcome in designing health policies in Brazil. Adopting established criteria from other parts of the world would be a significant advancement both in clinical management and in the accuracy of epidemiological assessment. The choice of criteria involves considering regional peculiarities and deliberating on which criteria are most appropriate or what adaptations should be made to ensure effectiveness as a public health tool in Brazil. The implementation of public health policies in remote areas would benefit from collaboration with non-governmental organizations or local leaders, considering that the prompt implementation of treatment measures is essential for reducing morbidity and mortality in cases of bee stings, particularly in instances of mass stings.

The epidemiology of bee stings in Brazil is significantly influenced by regional factors, reflecting variations in incidence, severity, and response to treatment in different areas of the country. The limited depth of data recorded in SINAN only allows for a general overview of bee sting incidents in Brazil. There is an urgent need to detail these data, both to understand the reasons for the increasing incidence of these incidents and to determine regional peculiarities and possible seasonality of these occurrences with health implications. The imminent approval of the use of anti-apitoxin serum produced by the Vital Brazil Institute further underscores the relevance of this type of study, whose results are essential for logistical distribution, especially in remote areas with difficult access to urgent healthcare services.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Authors hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

CONSENT AND ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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