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Short Communication

Visceral Leishmaniasis and Disposal of Solid Waste in Minas Gerais, Brazil

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Abstract

Visceral leishmaniasis (VL) is a vector-borne disease that is caused by the protozoan *Leishmania infantum* and transmitted to humans and other mammals through the bites of infected female sandflies. VL has been prevalent in Minas Gerais, Brazil, since the 1940s. As the vector completes its reproductive cycle in the soil with organic matter, the association between the occurrence of VL and unimproved solid waste disposal sites has been investigated. Thus, in this study, we analyzed the relationship of waste disposal conditions, inadequacies in disposal, and waste collection with the rates of VL, using statistical regression models. A case-control study was conducted to elucidate the relationship between VL and waste management; sick individuals (*cases*) were compared to healthy individuals (*control*), to determine the cause, by constructing a multiple regression model to analyze data through

a stepwise method. In Minas Gerais, according to the reports of the government in 2017, 60.1% of the urban population has access to an adequate final disposal system for urban solid waste, with an increase of 2.3% compared to the size of the disposal system in 2016. Thus, almost 40% of the population is forced to use poor or unimproved waste disposal sites. The results confirmed the direct relationship between VL and the unimproved disposal of solid waste in the municipalities (waste coverage collection: $p = 0.004$; waste found in the streets: $p = 9.69 \times 10^{-13}$). These rates also indicated that the proper management of wastes can help to combat VL by considerably reducing the breeding sites of sandflies, curbing adverse health effects, and improving the health of the population.

Keywords
Solid waste management; visceral leishmaniasis; Brazil

1. Introduction

The availability of basic sanitation services (e.g., water treatment and supply, improved sanitation services, solid waste management, urban drainage services, etc.) are essential for improving public health in rural and urban settings [1, 2]. Solid waste management, which continues to be a major issue in Brazil, can considerably improve public health. Approximately 29 million tons of garbage are improperly disposed of per year in Brazil [3]; thus, improving the health infrastructure is extremely important for controlling and combating diseases [2]. Visceral leishmaniasis (VL) is a chronic disease that, if left untreated, causes death in most cases. It commonly occurs around unimproved solid waste disposal sites [4].

VL has been affecting individuals in the state of Minas Gerais, Brazil since the 1940s. Initially, the disease typically occurred in rural areas, but drastic changes occurred over time with the expansion of endemic areas, leading to the urbanization of the disease [5]. According to the Brazilian Unique Health System [6], currently, there is a significant number of VL cases in the state of Minas Gerais. Moreover, the municipal solid waste destination in Minas Gerais found that only 57.8% of the urban population had regularized systems services for the final disposal of wastes. This indicated that almost 40% of the population probably suffered from exposure to poor or unimproved waste disposal sites and possible vector-borne diseases [7], like leishmaniasis.

Visceral leishmaniasis is a serious zoonotic disease that is prevalent in Latin America and caused by the protozoan *Leishmania infantum*. The parasite is transmitted through the bite of infected female sandflies. The prevalence of this disease is increasing globally, and Brazil is one of the six countries that contribute to more than 90% of all recorded cases worldwide [4, 8]. VL has significant clinical manifestations and, without treatment, contributes to high mortality rates [9, 10]. In Brazil, the sandfly *Lutzomyia longipalpis* is the main vector of *Leishmania infantum*. The insects use humid, shady places and soil, rich in organic matter, to reproduce [11-13]. Thus, open-air waste sites, which arise due to unimproved solid waste management, are ideal for vector proliferation in urban centers. Such findings highlight the intrinsic relationship between poor solid waste management and failure to control diseases [11, 14]. Moreover, according to the Ministry of Health (2019) [11], vector control in Brazil is performed by haphazard urban cleaning and correct procedures for disposing of

waste, along with the promotion of insecticide application. These measures cannot avoid the serious health effects that arise due to leishmaniasis.

Therefore, in this study, we investigated the unimproved sanitation services in the State of Minas Gerais, Brazil, focusing on the disposal of solid waste and the exposure to VL as a risk factor.

2. Methods

We conducted the study in Minas Gerais, which is one of the federative units of Brazil. The state had an estimated population of 21,292,666 in 2020. It is subdivided into 853 cities, covering an area of 586,521 km² [15]. The state has rugged topography, with high peaks and many rivers that are used for energy supply, agricultural activities, and tourism. Data were collected and analyzed from 92 (10.8%) municipalities of the 853 municipalities of Minas Gerais, where the incidence of the disease was reported in 2017.

A case-control study was conducted to determine the relationship between VL and waste management. Data were collected based on the identification of the disease in sick individuals (*cases*). These individuals were compared to healthy individuals (*control*) to determine the cause of the disease. Data provided by Feam [7] (2017) regarding the types of solid waste disposal in municipalities of Minas Gerais were used; these included landfills, controlled landfills, open-air dumps, and sorting and composting units. Confirmed cases of VL in the state were analyzed in 2017, according to DATASUS (2019) [6], to determine the relationship between the disposal of waste and the cases of VL recorded in the same year. The personal information of no patient was available in the database.

We asked three questions in this study: 1) What is the odds ratio (OR) of the municipalities for reporting cases of VL that do not have landfill services? 2) Is the absence of a landfill or improved waste management (see: Brazilian National Solid Waste Policy Law 12.305/2010) associated with cases of the disease? 3) What is the relative risk of recording positive cases of VL in municipalities that do not have landfill services?

To perform calculations and determine the RR and OR values, a table was constructed that showed the values based on the number of sick and non-sick individuals in the municipalities of Minas Gerais (Table 1). The results were interpreted as follows—if the values were higher than one, there were risk/chance factors, while if they were less than one, there was a protection factor [16].

Table 1 The number of cases of visceral leishmaniasis (VL) and controls according to the presence or absence of a landfill.

Landfill for waste disposal	Infected by VL	No infected by VL	TOTAL
No	236	2,479,502	2,479,738
Yes	625	7,901,084	7,901,709

Data on socioeconomic factors, waste management services, and rates of VL were also recorded to determine the variables that might be associated with higher rates of disease infection. These included: the score (the quality of waste disposal services by the municipality) of waste management provided by the environmental agency of Minas Gerais, the quantity of waste collected, the total area of waste collection, the population of the municipality, the human

development index (HDI), the income average adjusted per family, and the GINI coefficient (economic inequality population).

Finally, a multiple regression model was constructed to analyze the data through the stepwise method, which excluded less significant variables per stage and adopted the results with a 95% level of significance. After all the steps in the stepwise exclusion method were performed, only significant variables were used. Multicollinearity was tested in the model to validate the results. All statistical analyses were performed using the R software (version 3.5).

3. Results and Discussion

Data regarding the disease rate in the 92 municipalities suggested that 58% of these areas suffered from inadequate or unimproved waste disposal [7]. Only 38% of the municipalities with VL cases disposed of the waste in a landfill, which is considered to be a better waste disposal method according to the Brazilian National Solid Waste Policy [17].

The OR and RR of a municipality without a landfill, as well as, the registered cases of VL, were calculated (Table 1).

We also considered the data on socioeconomic factors (e.g., household average income) and waste services and constructed a multiple regression model. We found a positive relationship between VL cases, the population, and the quality and type of waste services (Table 2).

Table 2 A multiple regression model was constructed based on socioeconomic factors, waste management services, and rates of visceral leishmaniasis.

Variables	Visceral leishmaniasis					
	Initial model			Final model		
	Coef	S.E.*	P	Coef	S.E.*	P
(Intercept)	6.7924	8.2994	0.4135	0.6020	0.4591	0.1902
Human Development Index	-21.8670	21.1860	0.3025	-	-	-
GINI coefficient (economic inequality population)	2.7022	3.7528	0.4718	-	-	-
Population	0.0001	8.51E-06	2.20E-16	1.01E-04	9.57E-06	2.20E-16
Household average income	0.0170	0.0165	0.3035	-	-	-
Waste management quality	-0.0992	0.1251	0.4317	-	-	-
Precarious sanitation	0.0135	0.0156	0.3878	-	-	-
Waste coverage collection	-0.0160	0.0149	0.2833	-0.0202	0.0070	0.0041
Amount of waste collected	-0.3506	0.3580	0.3278	-	-	-
Waste found in the streets	0.0006	0.0001	1.50E-13	0.0006	0.0001	9.69E-13
Vif Maximum	3.83			2.55		
R^2	58.88%			57.83%		

* Heteroskedasticity-Consistent

The results obtained (Table 1) for both parameters indicated that OR = RR = 1.20. Thus, a municipality without an improved waste management strategy (e.g., landfill) has a 1.2 times higher chance of contracting VL compared to the municipalities that have this type of waste management strategy. Similar to our findings, Melchior et al. (2017) [18] reported that waste disposal was associated with greater cases of American cutaneous leishmaniasis in the state of Acre. This infection is prevalent in the central region of Vale do Acre and its high incidence rate has affected Brazil.

Typically, in Minas Gerais, the final solid waste is disposed of through four different modalities, including landfill, controlled landfill, sanitary landfill, and treatment and composting unit [7]. Our results showed that the southeast region of the state has the highest percentage of the urban population. This region has regularized destination services, suggesting that most of the waste is disposed of adequately. However, many municipalities, mainly in the north and northeast, dispose of their waste in landfills instead of using improved waste management services. This is a concern for public and environmental health outcomes since this type of waste disposal is associated with high rates of diseases like leishmaniasis.

According to the data from DATASUS [6], in 2017, many cases of VL were reported in Minas Gerais, which showed a high incidence of the disease along with many deaths in that year. The incidence rate per 100,000 people was 1.5, and the associated number of deaths was approximately 50 people reported deaths/100,000. Moreover, this confirmed that cities from the north and northeast regions of the state had a higher number of cases compared to the cities in other regions [6]. This information indicated the poor condition of waste disposal in the northern region and a high number of confirmed cases of VL.

Our results (Table 2) also suggested that unimproved waste management is associated with wastes found on the streets, which confirmed inappropriate waste management in the municipality. A negative association was found between the waste collection coverage and reported disease cases, which indicated higher positive cases and lower waste coverage collection. These results were similar to those of other studies, which found that poor waste management is associated with higher cases of various vector-borne diseases [12, 18-21]. Studies on illegal solid waste disposal sites have also been conducted. The potential for an increase in the cases of leishmaniasis was reported by Vladmir et al. [13]. A study on zoonotic cutaneous leishmaniasis cases by Chelbi et al. [22] found a relationship between illegal waste spots and a high risk of the disease, including the spread of the disease to neighboring home ranges in Central Tunisia. This is a research topic that might be further investigated in Brazil.

Bigeli et al. [23] highlighted the importance of sanitation as it can influence the occurrence of VL, suggesting that a lack of sewage and solid waste collection can lead to more cases of the disease. This hypothesis has been confirmed by other studies, including those on cutaneous leishmaniasis [12, 19, 22]. Cruvinel et al. (2020), highlighted the vulnerability of waste pickers to vector-borne diseases, such as those transmitted by *Aedes aegypti*, due to poor sanitary conditions at their homes and workplaces. Such studies showed that solid waste disposal and improved waste management (e.g., landfills) not only influence the rates of leishmaniasis but also promote other diseases. Lima [24] (2017) found that the increase in rainfall influences the incidence of VL, i.e., for every 100 mm

of additional rainfall, there is an annual increase in the disease by approximately 0.6 per 100,000 inhabitants. Dogs (*Canis familiaris*) are the main domestic reservoirs, generally preceding human infection [25, 26]. Thus, the movement of dogs in dumps and urban centers, along with the presence of organic matter related to trees and the lack of environmental sanitation might play an important role in VL endemicity. Also, in India, Dinesh et al. [27] reported on environmental management performed in indoor breeding sites, which significantly reduced the sandfly density (*Phlebotomus argentipes*, the vector of VL).

Finally, health literacy regarding the disease and the sandfly vector also needs to be addressed. Tamiru et al. [28] found that only 12.5% of the participants understood the link between organic material, like waste, and the rates of diseases. However, in another part of the world, Terefe et al. [20] reported higher health literacy rates, where 98.9% of the participants understood that open-air waste disposal was related to a higher occurrence of leishmaniasis. The rates of health literacy in Brazil regarding unimproved waste management and diseases need to be further investigated.

This study had some limitations. First, determining the cause-effect relationship might not be possible by analyzing only these results due to the complexity of the variables investigated (local analysis, including all municipalities, is recommended). Another limitation was the lack of generalizability of the main findings in Minas Gerais, although our results showed an association between variables.

4. Conclusion

Unimproved solid waste disposal is an important risk factor for VL cases in Minas Gerias, Brazil that can be improved through environmental management, as performed in some areas under the national policies. In this study, we compared improved and unimproved waste management in areas affected and unaffected by VL. This might be effective in controlling VL by reducing the breeding sites of sandflies through environmental management.

Our results showed the benefits of adopting the Brazilian National Solid Waste Policy, which recommended the use of landfills as the correct method for waste disposal. Unimproved disposal of waste, such as open-air dumps, has negative social and environmental implications for affected populations. Improving waste services and management can improve public health.

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Authors Contributions

Conception and design: KDR and RSJ. Data analysis: KDR, TRZ, RSL, SC, RSJ, and MPGM. Manuscript drafting: KDR. Manuscript revision: TRZ, RSL, SC, RSJ, and MPGM. Final version approval of the manuscript: All authors.

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Competing Interests

The authors declare that they have no competing interests.

Availability of Data and Materials

The datasets generated and/or analyzed during the current study are publicly available.

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