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*Original Article*

# Impact of socioeconomic status on the knowledge, attitudes, and practices about visceral leishmaniasis among dog owners

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## Abstract

Introduction: This cross-sectional study evaluated the impact of socioeconomic status on the knowledge, attitudes, and practices (KAP) concerning zoonotic visceral leishmaniasis (VL) among dog owners from the municipality of Rondonópolis—a highly endemic area for the disease in Central-Western Brazil.

Methodology: Data were collected between 2016 and 2017 during a household survey. A probabilistic sample of 404 dog owners were interviewed assessing sociodemographic characteristics, previous occurrence of VL cases, and KAP about human VL, vector, and canine VL. Responses regarding KAP were compared among social classes, which are indicators of socioeconomic status. Correct/appropriate answers were scored, and a multivariate Poisson regression analysis evaluated the impact of social class on scoring.

Results: The overall KAP regarding VL was limited. Dog owners from higher social classes differed from those of the lower classes regarding the recognition of abdominal distension ($p = 0.026$) and skin lesions ($p < 0.001$) as clinical manifestations of human and canine VL, respectively, knowledge of VL transmission ($p = 0.020$), use of topical repellents ($p < 0.001$), use of insecticide-impregnated collars ($p = 0.003$), and previous attempts of treatment for canine VL ($p = 0.005$). Higher scores were associated with the upper social classes (IRR = 1.18; CI = 1.08-1.29) adjusted by the age (IRR = 1.13; CI = 1.04-1.24) and the previous occurrence of human (IRR = 1.21; CI = 1.07-1.36) and canine (IRR = 1.25; CI = 1.14-1.36) VL in the household/neighbourhood of the respondents.

Conclusions: Improved KAP concerning VL was associated with better socioeconomic status of dog owners.

**Key words:** Visceral leishmaniasis; dogs; knowledge; attitudes; practice; socioeconomic factors; impregnated collars; treatment.

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## Introduction

Visceral leishmaniasis (VL) is a neglected tropical disease caused by a systemic infection by the protozoa of the genus *Leishmania*. It occurs in more than 80 countries through anthroponotic or zoonotic transmission cycles. Brazil is the most relevant endemic area for zoonotic VL worldwide [1]. In Brazilian urban settings, domestic dogs are considered the main reservoir hosts of *Leishmania (Leishmania) infantum*, which is transmitted to humans through the bite of phlebotomine sand flies (Diptera: Psychodidade) [2].

Based on this transmission chain, the Brazilian Ministry of Health implemented the VL Surveillance and Control Program (VLSCP) nationwide. The program is mainly focused on timely diagnosis and treatment of human cases, monitoring and control of vectors, and dog management [2]. Although preventive tools to cause a positive impact on canine infection and canine disease progression have been licensed in Brazil, such as vaccination, use of insecticide-impregnated collars, and treatment with miltefosine, these items are not yet covered by the VLSCP because of the lack of evidence to support their incorporation as large-scale policies [3,4]. Thus, dog management in the scope of public health is currently performed by the screening and euthanasia of seropositive dogs [2].

However, these strategies are proving to be inefficient in controlling the disease. The number of Brazilian municipalities reporting autochthonous VL has been increasing substantially in recent years [5]. In addition, the annual incidence of human VL and the prevalence of canine VL remain high, especially in the Northeast, Southeast, and Central-West regions of the country [5,6]. This failure of the VLSCP can be

partially explained by the high operational cost of the measures and low population engagement, especially regarding dog management [3].

The acquisition of knowledge concerning a disease and its prevention allows the expansion of individual critical and reflexive views, which directly improves participation and adherence to a control program [7]. In fact, according to the World Health Organization [8], health education and community participation are required to successfully control VL. Thus, it is important to assess the popular knowledge, attitudes, and practices (KAP) regarding the disease to identify gaps that should be targeted to drive appropriate, lasting, and cost-effective interventions [8-10]. Given the relevance of domestic dogs for the occurrence of zoonotic VL in urban settings, dog owners should be considered as a priority in these investigations. However, most of the previous studies carried out in Brazil are aimed at other groups, such as students [11], health professionals [12], and the general population [10,13].

The occurrence of zoonotic VL is more frequent among the poorest populations [14,15]. It seems that unfavourable living conditions may collaborate with ecological factors that favour the breeding of sand flies in domestic microenvironments and surrounding areas [16]. For other vector-borne diseases, it has been observed that individuals with low socioeconomic status have limited knowledge about the disease and less access to prevention and control measures [17,18]. Nonetheless, little is known about the impact of socioeconomic status on the population's knowledge and preventive practices related to zoonotic VL. Therefore, this study aimed to evaluate the impact of socioeconomic status on KAP concerning VL among dog owners from an endemic area in Central-Western Brazil.

## Methodology

*Study design and area*

This was a household-based cross-sectional study conducted between 2016 and 2017 with dog owners from the urban area of the Brazilian municipality of Rondonópolis.

Rondonópolis is a large municipality (236,042 inhabitants in 2020) located in the state of Mato Grosso in Central-Western Brazil [19]. Its urban area is composed of 230 neighbourhoods with remarkable socioeconomic and infrastructural differences. In 2003, Rondonópolis reported the first autochthonous case of human VL, but a major urban outbreak was observed only four years later. Since then, the measures recommended by the VLSCP have been implemented locally. Despite this, the municipality reported 210 autochthonous human VL cases from 2003 to 2016 [20] with high lethality rates [21]. A high canine VL seroprevalence (19.2%) was recently described among domestic dogs [20], with odds of seropositivity twice as high when the dog owners were from low social classes [15].

*Data collection and study population*

Data were collected during a canine VL serological survey performed within the urban area of Rondonópolis. As previously described [15,20], households were considered units for sample size determination and sampling procedures. Briefly, the survey covered a probabilistic sample of 416 households, which were randomly selected from 25 regions with different socioeconomic and environmental characteristics throughout the municipality. Home visits for data collection were performed from October 2016 to February 2017. Households with at least one living dog whose owner consented to join the study were eligible. A dog owner was defined as that person 18 years of age or older who were responsible for the animal. If the eligibility criteria were not met, the next household located to the right within the same block was visited. This amounted to 405 households enrolled in the present study.

One dog owner per household was interviewed using a structured questionnaire, which was elaborated based on previous surveys conducted elsewhere. The questionnaire was composed of multiple-choice and open-ended items that addressed (i) sociodemographic characteristics, i.e., sex, age, occupation, and level of schooling; (ii) aspects of the household, i.e., public water supply, street paving, and the number miscellaneous items (bathroom, maid, car, motorcycle, dishwasher, fridge, freezer, microwave oven, washing machine, tumble dryer, computer, and DVD player); (iii) the previous occurrence of human or canine VL cases at the household and neighbourhood; and (iv) KAP related to human VL (i.e., transmission route and clinical manifestations), vector (i.e., popular name, recognition, spraying chemical insecticides, use of topical repellents, and use of bed nets and windows screen), and canine VL (i.e., clinical manifestations, awareness about the reasons why euthanising dogs with canine VL is currently recommended by the VLSCP, choosing for euthanasia, prior screening for canine VL, vaccination against canine VL, use of insecticide-impregnated collars, and previous treatment of a dog with canine VL).

It is noteworthy that the questionnaire was pre-tested in a sample of 50 dog owners prior to this study. In addition, only two well-trained interviewers performed data collection to reduce variability in data recording.

*Data analysis*

Data were coded and doubly input in Microsoft Office Excel 2013 (Microsoft Corp., Redmond, OR, USA). Answers to open-ended questions were grouped according to similarity, as far as possible.

Socioeconomic status refers to the economic and social standing of an individual or group unit [22]. It is usually measured by determining education, income, occupation, housing conditions, and household amenities [23]. However, this definition depends on the research question and the measures available to the researchers [22]. In this study, the well-known and validated score of the Brazilian Association of Research Companies [24] for social class definition was employed as an indicator of the socioeconomic status of dog owners. The socioeconomic score was calculated considering the level of schooling, the number of miscellaneous items existing in the household, access to the public water supply system, and street paving. Based on predetermined cut-off points, dog owners were stratified into six social classes, namely A, B1, B2, C1, C2, and D-E [24]. The closer to A, the higher the social class; therefore, the better the socioeconomic status [15].

A descriptive analysis was performed to determine the absolute and relative frequencies of the answers regarding KAP on VL. The results were summarised for all participants and stratified according to the social class of dog owners. The chi-square test or Fisher's exact test were employed to compare the proportions of answers between high (A/B1/B2/C1) and low (C2/D-E) social classes. Differences with $p$-value $< 0.05$ were considered significant.

To better understand the effect of socioeconomic status on KAP, a score given the recorded answers was established. For that, all correct/appropriate responses about KAP on VL were scored with one point, whereas zero was assigned for incorrect/inappropriate or "do not know" responses, as proposed by Melkamu *et al*. [25]. Answers regarding a previous treatment of canine VL were not considered for scoring, as the drug used for this purpose was not accessed. This amounted to a maximum score of 32 points.

Our major hypothesis was that the level of KAP on VL was associated with the socioeconomic status of dog owners. Thus, we compared the aforementioned score between the high and low social classes using the Mann-Whitney U test. In sequence, the score was modelled as a function of social classes using the Poisson regression. In addition, as an attempt to consider the influence of the previous occurrence of VL on the current KAP, the previous reports of human and canine VL cases at the household or neighbourhood were defined as confounders. Sex and age group of the respondents were also employed as confounders.

After an initial univariate analysis, variables with $p < 0.20$ were considered for multivariate modelling. The final model was developed using a stepwise forward approach with the maintenance of variables with $p < 0.05$. The Akaike information criterion was employed to assess the effect of adding predictors and interaction terms on the model fit. In addition, the final model was checked using a goodness-of-fit chi-squared test. In both stages of modelling, the incidence rate ratio (IRR)

**Table 1.** Frequency distribution of dog owners according to sociodemographic characteristics, social class, and previous occurrence of human and canine visceral leishmaniasis. Rondonópolis, Mato Grosso State, Brazil (2016-2017).

| Variable | n (%) |
|---|---|
| **Sex** | |
| Male | 129 (31.9) |
| Female | 275 (68.1) |
| **Age group (years)** | |
| 18 – 40 | 145 (35.9) |
| 40 – 60 | 169 (41.8) |
| ≥ 60 | 90 (22.3) |
| **Educational level** | |
| Illiterate – primary school (incomplete) | 55 (13.6) |
| Primary school | 102 (25.3) |
| Elementary school | 76 (18.8) |
| High school | 130 (32.2) |
| College | 41 (10.1) |
| **Occupation** | |
| Employed | 171 (42.3) |
| Housewife | 111 (27.5) |
| Retired | 77 (19.1) |
| Unemployed | 36 (8.9) |
| Student | 9 (2.2) |
| **Social class** | |
| D-E | 104 (25.7) |
| C2 | 103 (25.5) |
| C1 | 88 (21.8) |
| B2 | 86 (21.3) |
| B1 | 18 (4.5) |
| A | 5 (1.2) |
| **Previous case of human VL in the household or neighbourhood** | |
| Yes | 54 (13.4) |
| No | 350 (86.6) |
| **Previous case of canine VL in the household or neighbourhood** | |
| Yes | 153 (38.0) |
| No | 251 (62.0) |

%: relative frequency; VL: visceral leishmaniasis.

with 95% confidence interval (CI) was determined to assess the strength of the associations. All statistical analyses were performed in R studio 3.6.2 software [26].

## Results

Of the 405 dog owners enrolled in the present study, one refused to provide answers about socioeconomic characteristics. Thus, 404 individuals were considered for further analysis. Regarding sex, age group, educational level, and occupation, there was a predominance of females (68.1%), aged 40–60 years (41.8%), completed high school (32.2%), and employed (42.3%), respectively. D-E (25.7%) and C2 (25.5%) were the most frequent social classes, and the number of individuals by category gradually decreased towards level A. At least one previous case of human and canine VL was reported in the household or neighbourhood of 13.4% and 38.0% of the respondents, respectively (Table 1).

Almost all interviewees had already heard about VL (95.5%) (Table 2). However, most of them (73.0%) were unable to recognise the clinical features of the human disease. Fever (10.4%), skin lesion (a typical presentation of cutaneous leishmaniasis) (9.4%), and abdominal distention (4.7%) were the most cited clinical manifestations (Figure 1A). In contrast, a low percentage of individuals (34.7%) did not recognise at least one clinical manifestation of canine VL. Onychogryphosis (40.3%), skin lesion (27.0%), and alopecia (20.0%) were the predominantly named signs of canine disease (Figure 1B). With the exception of abdominal distension for human VL ($p = 0.026$) and skin lesion for canine VL ($p < 0.001$), no difference in awareness about VL clinical manifestations and the dog owner's social class was found.

More than half of the participants (59.2%) stated that VL was a vector-borne disease; the proportion of individuals that gave this response was greater in the upper social classes ($p = 0.020$). However, only 25.7% of dog owners reported knowing the vector. Of these, a small percentage were aware of its popular name (21.1%) and could identify a sand fly on the presentation of several insect specimens (26.9%). With

**Table 2.** Frequency distribution of responses provided by dog owners for questions pertaining to knowledge, attitudes, and practices about the vector of visceral leishmaniasis according to the social classes. Rondonópolis, Mato Grosso State, Brazil (2016-2017).

| Question | All individuals | | Social class | | | | *p*-value |
|---|---|---|---|---|---|---|---|
| | | | A/B1/B2/C1 | | C2/D-E | | |
| | n | % | n | % | n | % | |
| **Have you ever heard about VL?** | | | | | | | |
| Yes | 386 | 95.5 | 185 | 93.9 | 201 | 97.1 | 0.120[a] |
| No | 18 | 4.5 | 12 | 6.1 | 6 | 2.9 | |
| **Do you know how VL is transmitted?** | | | | | | | |
| Insect bite | 239 | 59.2 | 128 | 65.0 | 111 | 53.6 | 0.020[a,b] |
| Others / Not know | 165 | 40.8 | 69 | 35.0 | 96 | 46.4 | |
| **Do you know the insect vector?** | | | | | | | |
| Yes | 104 | 25.7 | 59 | 30.0 | 45 | 21.7 | 0.059[a] |
| No | 300 | 74.3 | 138 | 70.0 | 162 | 78.3 | |
| **What is the name of the insect vector?** | | | | | | | |
| *Flebótomo* / *Mosquito palha*[c] | 22 | 21.1 | 15 | 25.4 | 7 | 15.6 | 0.222[a] |
| Others / Not know | 82 | 78.9 | 44 | 74.6 | 38 | 84.4 | |
| Not know the vector | 300 | - | 138 | - | 162 | - | |
| **Can you identify the vector?[d]** | | | | | | | |
| Yes | 28 | 26.9 | 19 | 32.2 | 9 | 20.0 | 0.165[a] |
| No | 76 | 73.1 | 40 | 67.8 | 36 | 80.0 | |
| Not know the vector | 300 | - | 138 | - | 162 | - | |
| **Do you spray chemical insecticide on your household?** | | | | | | | |
| Yes | 264 | 65.3 | 138 | 70.0 | 126 | 60.9 | 0.053[a] |
| No | 140 | 34.7 | 59 | 30.0 | 81 | 39.1 | |
| **Do you use topical repellents on yourself?** | | | | | | | |
| Yes | 71 | 17.6 | 48 | 24.4 | 23 | 11.1 | < 0.001[a,b] |
| No | 333 | 82.4 | 149 | 75.6 | 184 | 88.9 | |
| **Do you use bed net or window screen?** | | | | | | | |
| Yes | 7 | 1.7 | 4 | 2.0 | 3 | 1.5 | 0.718[e] |
| No | 397 | 98.3 | 193 | 98.0 | 204 | 98.5 | |

%: relative frequency; VL: visceral leishmaniasis; [a] Chi-square test; [b] Significant differences between social classes at $p < 0.05$; [c] Portuguese terms for sand fly; [d] Four specimens of disease-transmitting insects (*Culex* spp., sand fly, *Aedes aegypti,* and kissing bug) were previously shown to the respondents by the interviewer; [e] Fisher's exact test.

regard to the chemical prevention of insects, 65.3% of the individuals reported using commercial insecticides in the household. The use of topical repellents and the use of bed nets or window screens were mentioned by only 17.6% and 1.7% of dog owners, respectively. The habit of using topical repellents increased with the social class of the participants ($p < 0.001$) (Table 2).

Given the KAP regarding canine VL, 34.9% of the owners did not know why the euthanasia of seropositive dogs was recommended by the VLSCP. Only 5.2% were aware that it was a measure to prevent disease transmission from dogs to humans, as canine VL has no proven cure. Despite this, most of the individuals stated that they would choose euthanasia if their current

**Figure 1.** Stacked bar chart showing the frequency distribution of responses provided by dog owners for questions pertaining to the clinical manifestations of human (A) and canine (B) visceral leishmaniasis according to the social classes. Rondonópolis, Mato Grosso State, Brazil (2016-2017). *Significant differences between social classes at $p$-value < 0.05.

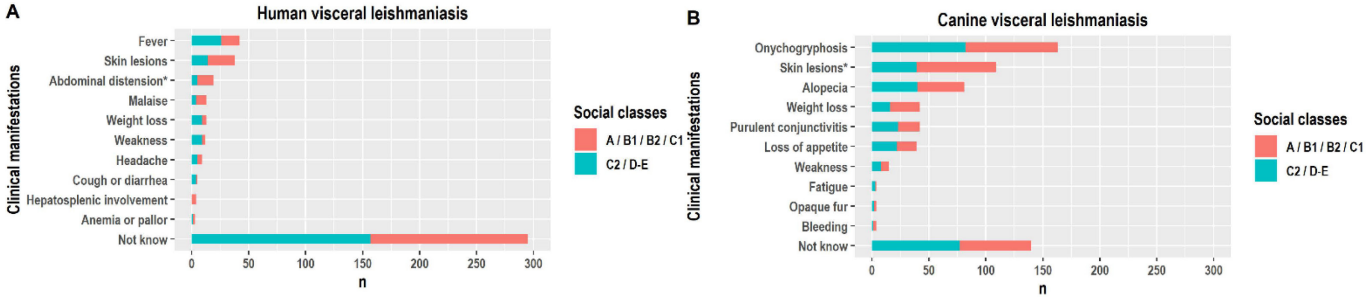


**Table 3.** Frequency distribution of responses provided by dog owners for questions pertaining to knowledge, attitudes, and practices about canine visceral leishmaniasis according to the social classes. Rondonópolis, Mato Grosso State, Brazil (2016-2017).

| Question | All individuals | | Social class | | | | *p*-value |
|---|---|---|---|---|---|---|---|
| | | | A/B1/B2/C1 | | C2/D-E | | |
| | n | % | n | % | n | % | |
| **Why euthanasia of animals with canine VL is currently recommended by the VLSCP?**[a] | | | | | | | |
| To prevent the transmission of the disease from dogs to humans | 160 | 39.6 | 78 | 39.6 | 82 | 39.6 | 0.579[b] |
| Because CVL has no proven cure | 58 | 14.4 | 30 | 15.2 | 28 | 13.5 | |
| To prevent the transmission of the disease from dogs to humans, as CVL has no proven cure | 21 | 5.2 | 13 | 6.6 | 8 | 3.9 | |
| Others | 24 | 5.9 | 13 | 6.6 | 11 | 5.3 | |
| Not know | 141 | 34.9 | 63 | 32.0 | 78 | 37.7 | |
| **Would you choose euthanasia if your current animal had canine VL?**[c] | | | | | | | |
| Yes | 281 | 73.6 | 129 | 70.5 | 152 | 76.4 | 0.192[b] |
| No | 101 | 26.4 | 54 | 29.5 | 47 | 23.6 | |
| Not know | 22 | - | 14 | - | 8 | - | |
| **Have you ever tested your current animal for canine VL?**[c] | | | | | | | |
| Yes | 54 | 13.4 | 27 | 13.7 | 27 | 13.0 | 0.845[b] |
| No | 350 | 86.6 | 170 | 86.3 | 180 | 87.0 | |
| **Have you ever vaccinated your current animal against canine VL?**[c] | | | | | | | |
| Yes | 6 | 1.5 | 4 | 2.0 | 2 | 1.0 | 0.648[d] |
| No | 395 | 98.5 | 192 | 98.0 | 203 | 99.0 | |
| Not know | 3 | - | 1 | - | 2 | - | |
| **Do you know the canine insecticide-impregnated collar?** | | | | | | | |
| Yes | 290 | 71.8 | 159 | 80.7 | 131 | 63.3 | < 0.001[b,e] |
| No | 114 | 28.2 | 38 | 19.3 | 76 | 36.7 | |
| **Does your current dog use the insecticide-impregnated collar?**[c] | | | | | | | |
| Yes / Already used | 55 | 13.6 | 37 | 18.8 | 18 | 8.7 | 0.003[b,e] |
| No | 349 | 86.4 | 160 | 81.2 | 189 | 91.3 | |
| **Have you ever treated an animal with canine VL?** | | | | | | | |
| Yes | 54 | 13.4 | 36 | 18.3 | 18 | 8.7 | 0.005[b,e] |
| No | 350 | 86.6 | 161 | 81.7 | 189 | 91.3 | |

%: relative frequency; VL: visceral leishmaniasis; VLSCP: Visceral Leishmaniasis Surveillance and Control Program; [a] This was an open-ended question. Provided answers were grouped according to similarity as far as possible; [b] Chi-square test; [c] For individuals who owned more than one dog with different response patterns between animals, at least one positive response was considered for classification; [d] Fisher's exact test; [e] Significant differences between social classes at $p < 0.05$.

animal had canine VL (73.6%). Moreover, a small proportion of owners had previously screened at least one of their dogs for canine VL (13.4%). Few participants also reported using measures not available in public health to prevent canine infection by *L. infantum*. In this context, the vaccination of animals against canine VL was performed only by 1.5% of the interviewees, whereas the use of insecticide-impregnated collars was reported by 13.6%, although most of them (71.8%) knew about the collars. In addition, 13.4% of the participants had already tried to treat an animal with canine VL. The use of insecticide-impregnated collars ($p = 0.003$) and previous attempts of treatment ($p = 0.005$) was more frequent among dog owners from high social classes (Table 3).

In general, the KAP scores regarding VL were low, ranging between 0 and 16 (median score: 5) points. Individuals from the upper social levels (median score: 5 points) presented scores significantly higher than individuals from lower social classes (median score: 4 points) ($p < 0.001$) (Figure 2). In fact, multivariate modelling revealed a significant association between scoring and social class. Respondents from levels A/B1/B2/C1 scored on average 18.0% (IRR = 1.18; CI = 1.08-1.29) higher than dog owners from C2/D-E. In addition, individuals who experienced previous cases of canine VL in the household or neighbourhood had an average 25.0% higher score than those who did not (IRR = 1.25; CI = 1.14-1.36). Previous human VL cases in the household or neighbourhood also significantly influenced the average score, although to a lesser extent (IRR = 1.21; CI = 1.07-1.36). Finally, respondents aged 40-60 y scored on average 13.0% (IRR = 1.13; CI = 1.04-1.24) higher than the younger ones (Table 4).

## Discussion

This study addressed the correlation between KAP about zoonotic VL and the socioeconomic status of dog owners in Brazil. In general, poor awareness and

**Figure 2.** Distribution of the score on knowledge, attitudes, and practices regarding visceral leishmaniasis among dog owners according to the social classes. Rondonópolis, Mato Grosso State, Brazil (2016-2017). *Significant differences between social classes at $p$-value < 0.05.

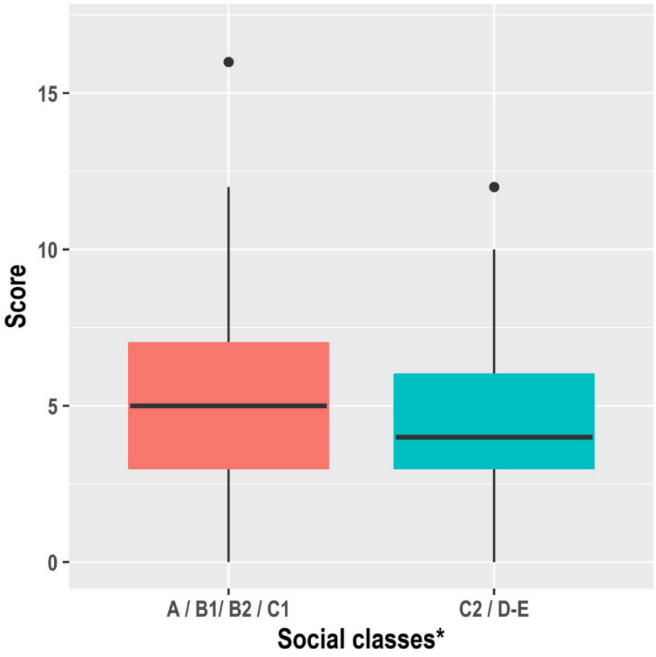


**Table 4.** Variables associated with the score on knowledge, attitudes, and practices regarding visceral leishmaniasis among dog owners in univariate and multivariate Poisson regression analysis. Rondonópolis, Mato Grosso State, Brazil (2016-2017).

| Variable | Univariate analysis | | | Multivariate model | | |
|---|---|---|---|---|---|---|
| | IRR | CI | *p*-value | Adjusted IRR | CI | *p*-value |
| **Sex** | | | | | | |
| Male | 1 | - | - | - | - | - |
| Female | 1.08 | 0.98 - 1.19 | 0.112 | - | - | - |
| **Age group (years)** | | | | | | |
| 18 – 40 | 1 | - | - | 1 | - | - |
| 40 – 60 | 1.11 | 1.01 - 1.23 | 0.034 | 1.13 | 1.04 - 1.24 | 0.006 |
| ≥ 60 | 0.92 | 0.81 - 1.04 | 0.181 | - | - | - |
| **Social class** | | | | | | |
| A / B1 / B2 / C1 | 1.19 | 1.09 - 1.30 | < 0.001 | 1.18 | 1.08 - 1.29 | < 0.001 |
| C2 / D-E | 1 | - | - | 1 | - | - |
| **Previous case of human VL in the household or neighbourhood** | | | | | | |
| No | 1 | - | - | 1 | - | - |
| Yes | 1.20 | 1.12 - 1.42 | < 0.001 | 1.21 | 1.07 - 1.36 | 0.002 |
| **Previous case of canine VL in the household or neighbourhood** | | | | | | |
| No | 1 | - | - | 1 | - | - |
| Yes | 1.26 | 1.15 - 1.38 | < 0.001 | 1.25 | 1.14 - 1.36 | < 0.001 |

IRR: incidence rate ratio. CI: 95% confidence interval; VL: visceral leishmaniasis.

misconceptions regarding the disease and its prevention were observed in the municipality of Rondonópolis. However, improved knowledge and practices were more frequent among individuals with better socioeconomic status. As expected, by scoring the correct/appropriate answers, a better level of KAP regarding VL was associated with the upper social classes.

As already demonstrated in Brazil [13] and abroad [27], individuals with low socioeconomic status have less access to information, and consequently, poor knowledge about basic concepts of VL. In this sense, a low proportion of dog owners from lower social classes were able to recognize VL as a vector-borne disease. In particular, this gap may be due to the small size of sand flies, as well as their nocturnal habits and silent flight [8,12,28]. Anyway, the lack of recognition of the main transmission route of VL may hinder the adoption of individual and domiciliary preventive measures aimed at sand flies. Consequently, the poorest dog owners are more likely to favour vector breeding sites in their households. Along with the existence of susceptible dogs, this can lead to the formation of local *L. infantum* transmission cycles [16]. In accordance with this, previous studies performed in Rondonópolis have reported an association between canine VL and low social classes of dog owners (C2/D-E) [15], and between both human [29] and canine [15] VL and precarious environmental conditions of the backyard.

Poverty also seems to limit the acquisition of preventive tools not available in the scope of public health by dog owners. Although it was observed an overall low frequency of such practices, the use of topical repellents, insecticide-impregnated collars, and previous attempts of canine VL treatment were significantly higher among individuals from high social classes. This difference was certainly due to the high prices of these products, which makes their use difficult for dog owners with low socioeconomic status [3,30]. Several experimental studies have demonstrated the effectiveness of some of these measures in reducing VL occurrence [31], infectiousness of dogs [32], and vector population [33]. Because of this, their incorporation within the VLSCP has been recently encouraged, especially regarding insecticide-impregnated collars [3,31,33]. Given our findings, public health managers should prioritize policies that ensure free supply and broad access to the collars, mainly among the poorest populations.

The previous occurrence of human and canine VL cases in the household or neighbourhood of the respondents also significantly increased the score on KAP. It should be considered that the reporting of a human VL case triggers surveillance actions at the community level, which includes indoor spraying and canine VL serosurveys [2]. These measures are usually performed along with educational activities, which may explain the increased knowledge and practices among dog owners with some degree of familiarity with the disease. In addition, it is possible that the high severity of human and canine VL contributes to increasing the level of interest about the disease in an affected community.

Nonetheless, even representing a relevant VL endemic area, the clinical manifestations of the human disease were largely unknown in Rondonópolis. Moreover, many participants confused human VL with cutaneous leishmaniasis by pointing out skin lesions as a clinical sign, which could be explained by the overlapping of both leishmaniases in the municipality [34]. Poor knowledge of human VL clinical manifestations deserves attention since the early recognition of the disease is highly recommended by the VLSCP [2]. A community that is aware of the signs of VL is able to quickly refer suspected patients to health services to seek care [11]. This is pivotal in timely patient management and may help decrease case-fatality rates [8]. It is noteworthy that Rondonópolis has presented a high case-fatality rate due to VL [21] and a long time lag between the onset of the first symptoms and the diagnosis of VL [35] in recent years.

On the other hand, participants were more aware of the clinical manifestations of the canine disease. Costa *et al*. [36] also observed this behaviour in Northeastern Brazil, where 89.3% of the interviewees were able to identify the symptoms of VL among dogs. This was particularly expected because the signs of canine VL are more exuberant and more visible than those of the human disease [2].

One last point that should be highlighted is the KAP regarding dog management within the VLSCP. In general, dog owners were not fully aware of the role of canine euthanasia in controlling the disease. Even so, most of them reported that they would opt for euthanasia in cases of canine VL positivity. Nonetheless, serological screening of domestic dogs was not observed as a frequent practice, despite being conducted free of cost by the VLSCP [2]. Taken together, as reported by Sousa-Paula *et al.* [37] in Brazil, these results suggest that the failure of dog culling in controlling VL may also be related to a low screening coverage, rather than only a low acceptance of euthanasia by the community.

The main limitation of this study may be related to the collection of data through interviews, which may have underestimated some answers provided. In addition, this study did not evaluate other predictors (e.g., educational level and occupation) potentially correlated with our main outcome (i.e., score on KAP) to avoid multicollinearity. Despite this, the obtained results may serve as a basis for a better understanding of zoonotic VL occurrence in urban areas that have recently emerged as endemic for the disease. Therefore, this may be useful to guide and reflect on the actions advocated by the VLSCP. Given the knowledge of VL and its prevention as a protective factor for both human disease [9] and canine infection [6], emphasis is placed on the need for health education activities. Ideally, this awareness should involve the whole population of dog owners as poor awareness and misconceptions about the disease were detected. Nonetheless, in scenarios with a scarcity of human and material resources, our data support the prioritisation of educational activities among individuals from lower social classes and/or without previous contact with the disease. For that, it is recommended the establishment of partnerships between public health agencies and universities, the training of knowledge multipliers (e.g., community leaders, pre-schoolers, and community health agents), and the integration of health education actions aimed at VL with other endemic diseases (e.g., dengue, cutaneous leishmaniasis, and rabies). With these efforts, it would be possible to envisage better community engagement for VL control and surveillance.

## Conclusions

In conclusion, an overall lack of awareness and misconceptions about VL and its prevention were observed among dog owners from the municipality of Rondonópolis. However, improved KAP was associated with a better socioeconomic status of the participants. This emphasises the need for continuous and target health education and surveillance actions prioritising the poorest individuals.

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### Authors' contributions

AGC, JGGL, and CJFF conceived the study; AGC, JGGL, JVLD, and CJFF designed the study protocol; AGC, JGGL, and LDR carried out the data collection; AGC, JGGL, and LDR analysed the data; AGC drafted the manuscript; JGGL, JVLD, and CJFF critically revised the manuscript for intellectual content. All authors read and approved the final manuscript.

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