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Sanitation conditions as an epidemiologic indicator for American Cutaneous Leishmaniasis in the Brazilian Southwestern Amazon

Condições de saneamento como indicador epidemiológico para Leishmaniose Tegumentar Americana na Amazônia sul ocidental brasileira

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ABSTRACT

This paper analyzes the relationship between sanitation and electricity service conditions and American Cutaneous Leishmaniasis (ACL) in the Brazilian state of Acre. For this study we considered the cases reported in the Brazilian System for Disease Notification from 2001 to 2010, using Principal Component Analysis. The results suggest a direct association between ACL and inadequate housing conditions that increase the occurrence of the disease, such as water supply from river or lakes, rainwater storage, disposal of solid waste in vacant lots, and absence of electricity service, in rural areas; and absence of bathrooms and sanitation, in both urban and rural areas. An inverse association arises, mitigating the occurrence of ACL, in urban areas, by using septic tanks for sewage. The associations found in this study evidence that inadequate housing conditions contribute to increasing the population's exposure to the ACL vectors.

KEYWORDS: American Cutaneous Leishmaniasis; Principal Component Analysis; Rural Sanitation; Urban Sanitation; Electricity

RESUMO

Este estudo analisou as relações entre condições de saneamento e energia elétrica e a Leishmaniose Tegumentar Americana (LTA) no estado do Acre. Utilizou-se os dados obtidos do Sistema de Informação de Agravos de Notificação entre 2001 e 2010 para correlacionar variáveis por meio da técnica de análise de componentes principais. O resultado indicou associação direta entre LTA e características inadequadas de moradia que podem ser agravantes à ocorrência dessa doença, como o abastecimento de água em rios ou lagos, o armazenamento de água da chuva, a destinação dos resíduos sólidos jogados em terrenos baldios e a falta de energia elétrica, estas em áreas rurais; em áreas rurais e urbanas, a ausência de banheiro ou esgotamento sanitário; e em áreas urbanas, em associação inversa, amenizando a ocorrência da LTA, o esgotamento sanitário utilizando fossa séptica. As associações encontradas sugerem que as condições inadequadas de saneamento contribuem para o aumento da exposição da população aos vetores da LTA.

PALAVRAS-CHAVE: Leishmaniose Tegumentar Americana; Análise de Componente Principal; Saneamento Rural; Saneamento Urbano; Eletricidade

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INTRODUCTION

Health is the major resource for social, economic and personal development, as well as an important dimension of quality of life. Political, economic, social, cultural, environmental, behavioral and biological factors can either promote or hinder health[1].

Environmental factors play a key role in health, as the emergence of diseases, especially vector-borne, usually occurs as a consequence of environmental degradation. In that relationship interface between the environment and the health of a population, there is a field of knowledge referred to as "Environmental Health". It is responsible for understanding the health consequences of the human and environment interaction[2].

In Environmental Health the relationship between environment and health is almost exclusively dealt with in connection with sanitation[3], which has its primary objectives centered on public health and only more recently adopted an environmental focus[4].

The World Health Organization defines sanitation as the control of all factors of human beings' physical environment that exert or can exert harmful effects on physical, mental and social well-being. Water supply, sanitary sewage, public cleaning, rainwater drainage and vector control are considered sanitation actions[5]. The Brazilian Institute of Geography and Statistics (IBGE)[6] also includes in sanitation actions the discipline of land use and land cover changes and specialized works for protection and improvement of living conditions. Moreover, the availability of electricity is frequently placed next to sanitation conditions as an indicator of quality of life[7]. All these determinants compose the concept of environmental health.

Environmental sanitation and the availability of electricity are therefore comprehensive instruments of fundamental importance in disease prevention and quality of life, as they enable the conservation of the environment and the improvement of environmental quality in the dwellings and their surroundings[8]. There are numerous diseases related to lack of sanitation, among them American Cutaneous Leishmaniasis (ACL)[9].

ACL is caused by protozoa of the *Leishmania* genus. This disease presents several clinical forms, of which the most common are the cutaneous and the mucosal. The cutaneous (or tegumentary) form is characterized by localized or disseminated ulcerated skin lesions that appear after the insect bite. The clinical mucosal form can affect the mucous membranes of the nasal cavities, pharynx, larynx and oral cavity, months or years after the individual has presented the cutaneous form[10].

The epidemiological cycle of ACL is complex and includes the transmission through the bite of hematophagous female insects belonging to several species of the Phlebotominae subfamily, known as *birigui*, *mosquito-palha*, *tatuquira*, sand fly, among others. These vectors have predominantly twilight or night activity with short and silent flights. During the day, they stay in quiet, dark and humid places, sheltered from the wind. These places include crevices and spaces between stones, animal burrows, tree hollows, stables, chicken coops, warehouses and human dwellings[10].

Among the ACL reservoirs there are wild animals, such as some species of rodents, marsupials, edentates and wild canids, and domestic animals such as dogs, cats and horses, but there is no scientific evidence of the role of domestic animals as reservoirs[10].

The Northern Region of Brazil is important in the epidemiology of ACL due to its number of cases, with emphasis on the state of Acre, which in 2004 had the highest coefficient of detection: 257.41/100,000 inhabitants[10]. One study found that, in Acre, 75% of the cases are of the cutaneous clinical form and 25% of the mucosal form in the period between 2001 and 2006, out of 8,516 cases. When comparing two study periods, the prevalence rose from 55.7/10,000 inhabitants from 1992 to 1997 to 128.5/10,000 inhabitants between 2001 and 2006[11].

ACL may be related to factors associated with poor environmental sanitation actions, population displacement, housing conditions and access to health services. In many places, epidemiological surveillance actions, such as vector control, migrations and poor housing with the presence of reservoir animals favor the occurrence and spread of the disease[9,12,13].

The availability of electricity also influences the exposure to ACL, since it can affect the behavior of individuals, especially in rural areas. The presence of light associated with the breeding of animals in the vicinity of the residences are attractive factors for the Phlebotominae and increase the risk of ACL[14,15,16].

According to data from the IBGE demographic census[17] in Brazil, the Northern Region is the one that presents the country's worst indicators for basic public services related to water supply, sewage, solid waste collection and electricity. It is worth mentioning that rural areas present sanitation indicators that are far below those found in urban areas.

Therefore, basic utilities, such as sanitation and electricity, have the objective to achieve environmental sanitation, which is the state of sanity in which the population lives, both as regards their capacity to inhibit, prevent or avoid the occurrence of environmental endemic diseases or epidemics, as well as their potential to promote the improvement of environmental conditions conducive to the full enjoyment of health and well-being[18].

The impact of poor housing conditions and the lack of basic healthcare public services are becoming more frequent, especially in poorer communities. This worsens the occurrence of diseases directly or indirectly related to the absence of these services, such as ACL. The use of sanitation and electric power as instruments of health promotion presupposes overcoming the technological, political and managerial obstacles that have hampered the extension of the benefits to residents in rural areas, municipalities and small towns[18].

Considering the table presented, this study aimed to verify the relations between housing conditions, the existence of basic sanitation and the availability of electricity and the prevalence of ACL in the Brazilian state of Acre.

METHOD

The state of Acre is located in Northern Brazil, in the Southwestern Amazon. It has an area of 164,122,280 sq. km and is bordered by Bolivia, Peru and the Brazilian states of Amazonas and Rondônia. It has 22 municipalities, distributed in two mesoregions, Acre Valley and Juruá Valley, which encompass five microregions (MRs): Alto Acre, Médio Acre, Purus Valley, Tarauacá Valley and Juruá Valley[19].

To survey the prevalence of ACL, we used the database of the Information System for Notifiable Diseases (SINAN) of the Ministry of Health/Department of Health Surveillance, for the period from 2001 to 2010. As the criterion for inclusion, we considered all confirmed cases that showed the likely municipality of infection, in order to enable us to estimate the annual and average coefficient of detection for the period of 10 years per municipality. Population data was retrieved from IBGE estimates and censuses[17]. Data on sanitation was obtained from the 2010 demographic census[17] for the following topics in each of the 22 municipalities: water supply, waste disposal (solid waste), existence of electricity, existence of bathrooms or WCs and sewage. This data is available as a percentage and refers to residents in permanent private homes for each of the topics stratified in rural and urban areas. They were categorized as follows:

a. water supply: general network, well or spring, water trucks, stored rainwater, rivers, ponds, lakes or streams and others;

b. garbage destination: collected, burned, buried, thrown in wasteland or public place, disposed of in rivers, lakes or seas and another destination;

c. existence of electricity: they either had electricity or they did not have electricity;

d. existence of a bathroom or WC and sanitary sewage: general or rainwater network, septic tank, rudimentary tank, ditch, river, lake or sea, others and had neither bathroom nor WC.

For the existence of a bathroom or WC and sanitary sewage, the categories “had a bathroom” and “had a WC” were added, referring to the same type of sanitary sewer destination (for example, they “had a bathroom” - for exclusive use of the dwelling - ditch, added to “had a WC” - ditch).

In order to identify the municipalities with housing conditions that could present possible relationships between household variables and coefficients of detection of ACL, we carried out Principal Component Analyses. This technique uses the covariance matrix of the original variables extracting from it the eigenvalues that generate the eigenvectors, called principal components. The eigenvectors or principal components are linear combinations of the original variables. The greater their value, the greater the amount of the original variability. For the definition of the number of components to be considered, we used the Kaiser criterion, which only considers eigenvalues higher than a unit[20].

The statistical analysis was processed in the *Statistica* software, version 7[21], using a data set consisting of a matrix, with the percentage of residents in permanent private households for each of the categories of topics previously described for urban and rural areas, plus the detection coefficient, totaling 45 categories. The coefficient of detection was analyzed as a supplementary variable and, in this case, this variable was not used for extraction of the principal components, but it was mapped to the coordinate system (factorial structure) determined from the variables selected for the analysis. It was included in all result tables and charts. The variables were standardized, for each fixed j, through the formula: $z_{i,j} = \frac{I_{k,j} - \acute{I}_{k,j}}{s_j}$ where k indicates the group, j is variable and $\acute{I}_{k,j}$, respectively, the mean and standard deviation of the j variable.

The discriminatory power of each variable is measured by the equation: $r_{x_j}(cp_h) = \frac{a_{jh}\sqrt{\lambda_h}}{s_j}$ where r_{xj} (PC_h) is the correlation between the x_j variable and the PC_h principal component, a_{jh} is the coefficient of the j variable in the *h*-th principal component and λ_h is the *h*-th eigenvalue of the covariance matrix.

The percentage of the total variance contained in each PC_h component was obtained according to the equation: $CP_h = \frac{\lambda_h}{T(C)} 100$ where T (C) is the trace of the covariance matrix ($\lambda_1 + \lambda_2 + \ldots + \lambda_h$) and λ_h is the *h*-th eigenvalue of the covariance matrix.

RESULTS

The indexes of public services in the state of Acre evaluated in this study are all below the national average. When considering the indexes without separating the values between urban and rural areas, data indicates that only 45.65% of the dwellers have water supply connected to the general network, 71.21% have solid waste collection, only 21.93% have bathrooms or WCs connected to the general sewage or rainwater network and 91.50% have electricity. When the same information is analyzed by separating the dwellers according to urban or rural areas, it can be seen that the indexes in rural areas are much lower, as shown in Figure 1.

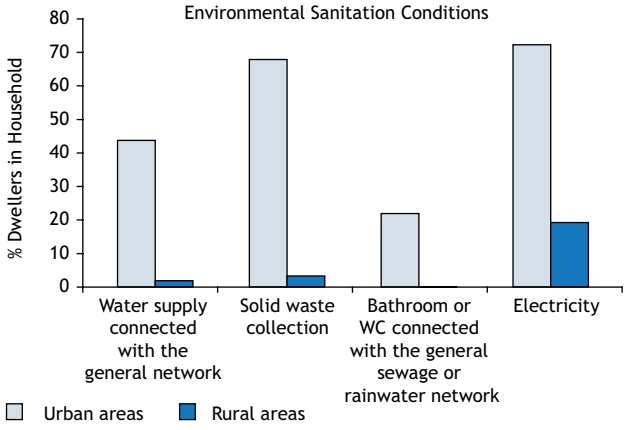


Figure 1. Percentage of residents served by public water supply, solid waste collection, and sanitary sewage and electricity in the state of Acre, according to urban and rural areas.

The principal component analysis enables us to understand the complexity of the data, since it retains the original variability of the information set. This retained variability gives rise to the principal components and, in this study, we considered two principal components that retained 40.69% of the original data variability. The principal components are Principal Component 1, named in the text as PC1, and Principal Component 2 (PC2), and the variability retained by each of them was respectively 21.88% and 18.81%.

The analysis was performed considering the ACL coefficient of detection as a supplementary variable, which allowed us to identify the variables that are directly associated with it.

The values of correlation coefficients of the characteristics of sanitation, electricity and ACL coefficient of detection with the principal components are in the Table. The coefficient of detection of ACL showed a higher correlation with PC2 (0.804) than with PC1 (0.515), which indicates that the sanitation categories that exert a greater influence on the prevalence of ACL are also associated with PC2, such as rainwater storage (A), the use of rivers, dams, lakes and streams (Ario), solid waste dumped in wasteland (Rjogter) and not having electricity (En), all for the rural area, while for the urban area the categories were not having a bathroom or WC (Sbn) and the presence of a septic tank (Sfs), although this was inversely correlated.

Figure 2 shows the two-dimensional biplot graph (distribution of municipalities' scores and projections of the variables).

According to Figure 2, the municipalities of Jordão, Santa Rosa do Purus, Marechal Thaumaturgo, Porto Walter and Tarauacá are the most discriminated by variables positively correlated with the PC2 component, mentioned above and listed in the Table, and which exert a strong influence on the prevalence of ACL, as evidenced by the projection of the coefficient of detection variable.

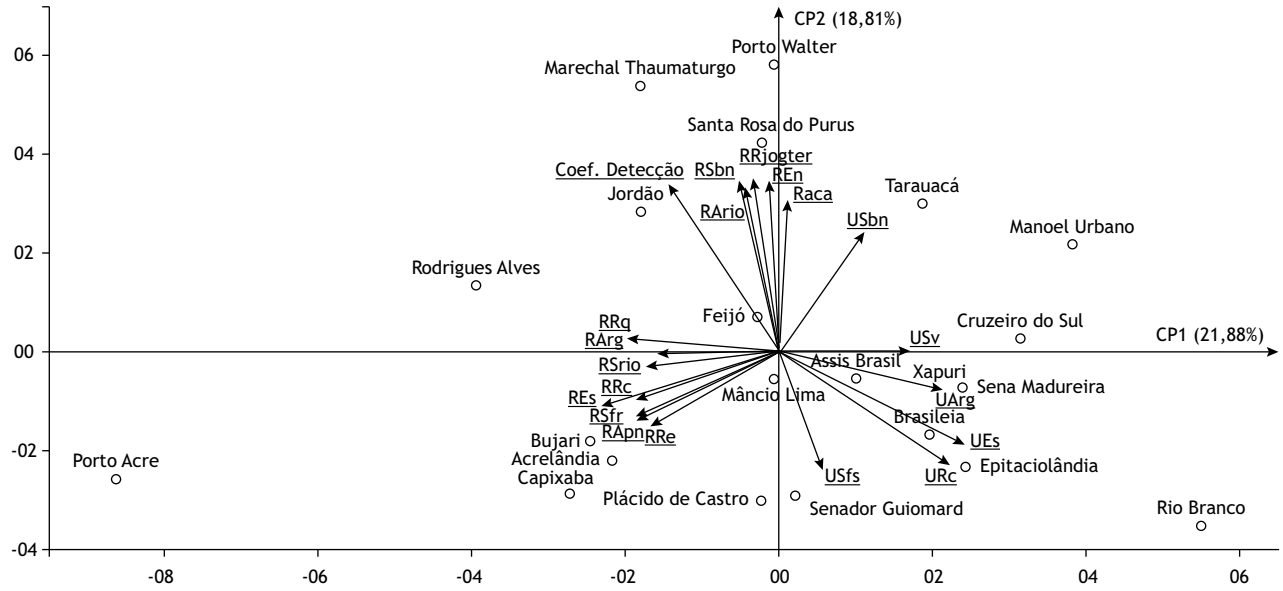
DISCUSSION

The process of environmental degradation associated with housing conditions and the lack of basic public utilities, such as environmental sanitation, plays an important role in the prevalence and incidence of infectious and parasitic diseases[22], such as ACL.

The type of housing is considered a risk factor for ACL. Poor housing conditions, with wooden walls and floors with cracks, may interfere with the epidemiological cycle, increasing the risk of infection[9,12,23].

Several studies on ACL in various Brazilian regions highlight housing conditions and environmental sanitation as characteristics associated with the occurrence of the disease, as we observed in a study by Condino[24], done in the north coast of the state of São Paulo, and in a study done by Passos et al.[25], in the metropolitan area of Belo Horizonte. ACL occurs in dwellings close to woods with animals, as reported by Santos et al.[14] in a survey carried out in the south of Bahia, Moreira et al.[26] in Maranhão, Castro et al.[27] in the north of Paraná and Guerra et al.[28] in Manaus, Amazonas.

The results found in the present study show a strong correlation between the variables of sanitation and the prevalence of ACL. Among the sanitation variables, the categories that directly



1st letter: R: referring to the rural area; U: referring to the urban area. 2nd letter: A: water supply; E: electricity; R: solid waste destination; S: sanitary sewage disposal. Lowercase letters: bn: does not have a bathroom or sanitary sewer; c: collected; ca: stored rainwater; e: buried; fr: rudimentary tank; fs: septic tank; jogter: thrown on vacant lot or backyard; pn: well or spring; q: burned; rio: collected or thrown in rivers, dams, lakes or streams; rg: general network; s: had electricity; v: ditch.

Figure 2. Two-dimensional plot of principal components 1 and 2 showing the distribution of the municipalities in the state of Acre and the characteristics evaluated.

Table. Correlations between sanitation characteristics, electricity and the ACL coefficient of detection and principal components, in the state of Acre.

Characteristics	Rural area (R)		Urban area (U)	
	PC1	PC2	PC1	PC2
* ACL coefficient of detection	-0.515	0.804	-0.515	0.804
Water supply (A)				
Stored rainwater (Aca)	0.046	0.732	0.247	-0.012
Rivers, dams, lakes or streams (Ario)	-0.159	0.787	0.047	0.452
General network (Arg)	-0.576	-0.013	0.778	-0.190
Well or spring (Apn)	-0.677	-0.326	0.470	-0.494
Water truck (Acp)	0.156	-0.353	0.478	-0.278
Other (Ao)	-0.270	0.393	0.432	0.559
Solid waste destination (R)				
Thrown in empty lot or backyard (Rjogter)	-0.132	0.833	0.466	0.418
Collected (Rc)	-0.679	-0.234	0.800	-0.553
Burned (Rq)	-0.720	0.055	0.303	0.342
Buried (Re)	-0.606	-0.364	0.051	-0.059
Thrown into a river, lake or sea (Rjogrio)	-0.026	0.445	0.396	0.223
Another destination (Ro)	-0.277	-0.343	0.338	0.222
Electricity (E)				
Did not have electricity (En)	-0.050	0.821	0.232	0.477
Had electricity (Es)	-0.837	-0.269	0.885	-0.454
Bathroom or WC and sanitary sewage (S)				
Did not have bathroom or WC (Sbn)	-0.186	0.827	0.408	0.571
Septic tank (Sfs)	-0.484	-0.545	0.197	-0.571
Rudimentary tank (Sfr)	-0.673	-0.346	0.380	-0.269
River, lake or sea (Srio)	-0.618	-0.073	0.384	-0.223
Ditch (Sv)	-0.448	0.505	0.619	-0.002
General sewage or rainwater network (Srg)	-0.323	-0.329	0.551	-0.350
Other (So)	-0.366	-0.069	0.158	0.144

*Supplementary variable.

correlated with the ACL coefficient of detection were: water supply from rivers, dams, lakes or streams, and stored rainwater, solid waste dumped in wasteland or public places, no electricity and no bathroom or WC in rural areas; and no bathroom or WC in urban areas. In general, these conditions of environmental sanitation favor the exposure of the population to the ACL vectors[12].

The only variable that correlated inversely with the ACL coefficient of detection was the septic tank in urban areas. This result may have occurred due to the fact that 21.93%[17] of the resident population in urban areas in Acre has sanitary sewage connected to the general sewage network. The use of a septic tank would be an effective alternative for the disposal of sanitary sewage, since it would be able to safely dispose of sanitary sewage[29].

The ACL coefficient of detection showed a positive correlation with the rural population whose water supply comes from rivers, dams, lakes or streams. When water is not piped, individuals need to move to the water sources. These sources are generally located in forest areas, habitat of the Phlebotominae, leading to an increased risk of ACL infection by constant exposure to the vectors.

The disposal of solid waste in empty lots and public places and the absence of sanitary sewage and bathrooms can create conditions for the development of the vector (Phlebotominae) in the domiciliary and peridomiciliary environments due to the accumulation of organic matter and humidity[30]. Solid waste exposure can also attract small wild mammals in search of food and these are potential reservoirs[9]. It is also worth noting that the lack of bathrooms causes individuals, especially in rural areas, to move to forest environments to defecate and urinate, leading them to exposure to the ACL vectors. The adequacy of the peridomiciliary environment with the adequate disposal of organic residues, the reduction of humidity, and the distancing from forests and animals can reduce de population of Phlebotominae in the peridomiciliary environment, as verified by Teodoro et al.[16]and Legriffon et al.[31], in Paraná.

Regarding the availability of electricity, studies carried out by Teodoro et al.[15] and Teodoro et al.[16] showed that the presence of light and animals in the peridomiciliary environment are attractive for the Phlebotominae. Santos et al.[14] suggested that the presence of light can change the behavior of the individuals, as they go to sleep later. This can increase the exposure time to the bites. However, in the present study, we demonstrated that factors such as the unavailability of electricity, coupled with the incorrect disposal of garbage, lack of sanitary sewage and bathrooms, wooden houses with cracks on the walls and on the floor and the presence of domestic animals, characteristics of the Amazonian dwellings[32], increase the exposure of individuals to the Phlebotominae.

ACL has a complex epidemiology and the conditions of sanitation and electricity are only some of the factors involved. Adequate environmental sanitation conditions did not seem to be significantly and inversely correlated with the coefficient of detection, except for septic tanks in urban areas, since other factors may also influence the epidemiology of this disease in the state of Acre.

The studies carried out by Teodoro et al.[16] and Teodoro et al.[33] have shown that methods of environmental organization and sanitation contribute to reducing the population of Phlebotominae in domiciliary and peridomiciliary environments by attenuating the transmission of *Leishmania* to men in the peridomicile, in endemic areas of ACL. Therefore, sanitation measures and the removal of domestic animals from the peridomicile are considered to be ancillary measures for the control of the Phlebotominae.

The concept of healthy housing applies from the drawing up of its design, micro-localization and construction, including its use and maintenance. It is related to the location, the geographic and social territory, the building process, the global context of the environment and the environmental health education of its residents about the styles and conditions of healthy living[22,34].

In order to achieve success in the fight against diseases like ACL, we need measures to allow the population access to adequate sanitary conditions and also tools that enable the evaluation of the impact of these improvements on the social, economic and health dimensions in a continuous process[13].

Therefore, housing conditions play an important role in the epidemiology of ACL, requiring the use of methodologies that provide conditions for the creation of health-friendly and health-promoting environments, such as healthy housing. In the process of building healthy housing, housing is understood as a space whose main function is to have the quality of being habitable, incorporating the vision of the multiple dimensions that make up housing: cultural, economic, ecological and human health[35].

CONCLUSIONS

The principal component analysis indicated the existence of an association between inadequate housing conditions and ACL. The following items can be considered as aggravating factors for the occurrence of ACL: water supply from rivers, dams, lakes or streams and stored rainwater, solid waste disposed of in empty lots of public places, having no electricity and no bathrooms or WCs in rural areas; and not having bathrooms or WCs in urban areas. These factors contribute to the increase of the population's exposure to the ACL vectors.

We emphasize the need for actions and education in environmental sanitation to improve home and peridomiciliary conditions, even in remote areas, to create healthy environments as an alternative to fight ACL in these localities.

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To Capes/Prosup.

Conflict of Interest

Authors have no potential conflict of interest to declare, related to this study's political or financial peers and institutions.