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The development and validation of a risk score for household infestation by *Triatoma infestans*, a Bolivian vector of Chagas disease

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ABSTRACT

Chagas disease, primarily spread in Bolivia by the vector *Triatoma Infestans*, persists as an important public health problem. Preventative insecticide campaigns target spraying on the basis of anecdotal evidence and there is a need for an accurate classification score to correctly identify 'at risk' houses.

Data were collected from 337 households on 11 variables through the use of a standardised questionnaire and survey. Risk factors for infestation were identified and a risk score was developed and validated on a separate cohort of 165 houses.

Five significant risk factors were identified: cracks in the walls of houses; adobe walls; junk in the peridomiciliary area; no insecticide spraying in the previous two years; and freely ranging animals. A risk score was generated and then calculated for each house. Three risk categories were defined: low, medium and high risk. In the development cohort the infestation rates were 2%, 18% and 69% respectively. The corresponding infestation rates in the validation cohort were 7%, 30% and 75% respectively. Sensitivity and specificity for this test were 81% and 84% and the positive predictive and negative predictive values were 71% and 90%.

The risk score developed could be used to inform decision making in underfunded multilateral preventative initiatives.

1. Introduction

Chagas disease, caused by the parasite *Trypanosoma cruzi* and primarily transmitted through the faeces of infected vectors, is responsible for a greater burden of disease in Latin America than all other vector-borne diseases combined.[1] Throughout the southern cone of South America, *Triatoma infestans* is the principal vector of *Trypanosoma cruzi* and is the sole vector in central Bolivia. Contact between those at risk of the infection and the vector commonly occurs due to household infestation.[2,3] Therefore, effective control of Chagas disease requires an understanding of vector ecology, transmission dynamics and risk factors for infestation in order to identify those at risk of this insidious disease.[4]

Since the introduction of the Southern Cone Initiative (SCI) in 1991, important advances in controlling *Triatoma infestans* have been achieved in this region. These are demonstrated in Uruguay, Chile and Brazil, where transmission by the main domiciliary vector has been halted throughout the previous two decades.[3,5] In line with this, Bolivia introduced a national vector control programme in 2000 including insecticide spraying of households, screening of blood banks and community education.[6] Despite a reduction in infestation and infection rates, data from 2005 still indicate that Bolivia remains Chagas' frontline with seven of its nine departments endemic.[6] Additionally, it

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has the highest rate of vector-borne transmission and the highest seroprevalence of *Trypanosoma cruzi*.[7,8]

Pyrethroid insecticide treatment campaigns are an integral part of these multilateral prevention initiatives and are a proven method of interrupting transmission of *Trypanosoma cruzi* to humans.[9] Unfortunately, such campaigns are under-resourced and cannot utilise widespread spraying. Cost-effectiveness of campaigns needs to be maximised by use of robust data on infestation risk to target spraying. Such data is currently lacking and there therefore appears a very real need for an accurate predictive tool grounded in robust scientific evidence to assess risk of infestation by triatomine bugs.

Numerous risk factor analyses have been carried out throughout the continent but there are no published data for Bolivia.[10–16] These studies describe the association between infestation and housing structural characteristics, animal interactions and spatial location of household. Although the studies were often large scale, the differences in their findings suggest that risk factors are region, vector species and culture specific. This study aimed to develop and validate a risk score for household infestation through the identification of specific risk factors for household infestation by *Triatoma infestans* in Bolivia.

2. Materials and methods

2.1. Study area

For the development of the score, data were collected across two distinct areas in the Cochabamba department of central Bolivia at an elevation of approximately 2500 m. Specifically, data were collected in Valle Hermoso, an impoverished urban district in the south of Cochabamba city and Sipe Sipe, a Bolivian rural village 50 km from Cochabamba city. Data were collected for the validation cohort from Yotala, a village in the Chuquisaca department of Bolivia. Both these departments are endemic for Chagas disease.

Most residential lots consist of a house, or a number of houses, surrounded by a walled and gated enclosure. Hereafter, the inside of the house, defined as the space contained within the main walls of the dwelling, will be referred to as the domiciliary area. The peridomiciliary area commonly consists of the surrounding garden/patio which is used by household members and ordinarily shares walls with neighbouring lots (definitions adapted from Ramsey et al.[13]).

2.2. Sample selection and population

All households within the areas described above were eligible to be included in the study. Households were excluded if they were not permanent residences (defined as occupied more than 5 days per week) or if there was no fluent Castilian speaker present (Latin American Spanish). In order to ensure this study examined a balanced spatial sample of households within these districts, they were divided into several sampling zones: six in Valle Hermoso; four in Sipe Sipe; and three in Yotala. This was based on the geographical profile of the study area and equality in the number of households. Furthermore, an approximately equal number of households were selected for surveillance from each zone, completed through enumeration and random selection of all streets within the sampling zones, followed by the random selection of residential lots on each street. If a selected household declined to participate, was not occupied, or had to be excluded for the reasons detailed above, the house directly to the right, followed by the house directly to the left, was approached. Only seven houses were excluded due to the lack of a fluent Castilian speaker and all houses were permanent residences.

2.3. Household evaluation

From January to March 2011, all participating households in the development cohort were studied to determine infestation and the presence or absence of 11 pre-specified household variables (Box 1). These were chosen as they have been found to be statistically significant following multivariate logistic regression in previous risk factor studies set throughout the continent.[10–16] Many of the variables selected were easily identifiable binary variables. This decision was deliberate, to ensure that any risk score produced was simple and suitable for mass use in the field. After obtaining informed consent, data were collected on infestation and the household variables through the use of a standardised questionnaire and survey. As all contact with participating households was communicated through Castilian, these tools were developed in conjunction with a native Bolivian Castilian speaker. To assess viability, they were piloted on 10% of the overall household sample and no changes were required. Infestation was defined as a report of *Triatoma infestans* in the domiciliary or peridomiciliary area in the last six months; a binary outcome. All participants were shown an accurate picture of an adult *Triatoma infestans* to confirm vector identity (sensitivity 88.4%).[17,18] If the house had undergone systematic insecticide spraying within the last six months, infestation was classified as a sighting of *Triatoma infestans* post insecticide treatment. The data collected for the questionnaire was obtained verbally, using a script for each question by the two lead researchers, who are fluent in Castilian, relating to

Box 1. Summary of household variables to predict infestation

House age
Number of residents
Number of animals kept on the plot
[a]Freely ranging animals between the peridomiciliary and domiciliary areas
Wall material
Plastered walls
[a]Crack(s) in the walls or ceilings (a crack is defined as any break in the wall/ceiling integrity exposing the underlying construction material)
Roof material
[a]Junk (any material not being employed in its primary function) pile(s) in the peridomiciliary area
Rodents in the peridomiciliary area (<6 months)
No insecticide spraying (<2 years)

[a]These potentially continuous variables were considered as binary in accordance with the relevant literature.[12–14]