Journal of Public Health: From Theory to Practice (2019) 27:723–732
https://doi.org/10.1007/s10389-018-1001-x

ORIGINAL ARTICLE

Socioeconomic profile and perceptions of Chagas disease in indigenous communities of the Paraguayan Chaco

Carmen Marina Arrom-Suhurt[1] · Cristina H. Arrom-Suhurt[1] · María Auxiliadora Arrom-Suhurt[1] · Miriam Rolón[1] · Maria Celeste Vega-Gómez[1] · Antonieta Rojas de Arias[1]

Received: 24 June 2018 / Accepted: 6 November 2018 / Published online: 21 November 2018

Abstract

Aims Chagas disease continues to be a problem in indigenous communities of the Paraguayan Central Chaco because of the high infection prevalence. The study area presents great environmental and biological diversity, high temperatures, low rainfall, poverty and rapid vector reinfestation. This descriptive study analyzed the demographic and socioeconomic profiles and knowledge, beliefs and attitudes toward Chagas disease in four indigenous communities.

Methods A household survey was used as an instrument for gathering information from 270 families as well as a survey of social networks, in-depth interviews and focus groups with key informants and four participatory diagnoses.

Results A high percentage of the studied population did not know about the disease (72%), but 80% of them identified the presence of the main vector in their homes. They had poor knowledge of the vector as an annoying bug to be eliminated (19%) and did not relate it to the disease. Half of the population thinks that there is no risk of contracting the disease, which could be curable (52.7%). Work activities were linked to Mennonite groups, and solidarity cooperation and mutual aid with exchanges of favors, mainly related to food, were common.

Conclusion There is no knowledge about Chagas disease in these communities because of different factors, including not associating symptoms with the disease, the predominance of ethnic languages, which limit the education process, and lack of access to public health. National Chagas Program efforts should be complemented by other programs with health education and improved learning conditions based on a comprehensive approach according to the rights and specific cultural characteristics of these populations.

Keywords Attitude · Chagas · Indigenous · Knowlegde · Populations · Poverty · Practices

Introduction

The current existence of Chagas disease as a health, social and economic problem that silently kills 14,000 people per year in Latin America is shameful (PAHO 2018). Although a hundred years have elapsed since its discovery, most of those affected do not have access to diagnosis and treatment (Zabala 2012; Dias 2006). This endemic disease affects poor rural areas of Latin America, mainly in Argentina, Bolivia, Paraguay and Brazil, where the prevalence of cases is high (Molina et al. 2016). Prevention efforts have produced an interruption of transmission by *Triatoma infestans* (vinchuca) in Uruguay, Chile, Brazil and, just recently, in all of Paraguay (WHO 2015; PAHO 2018). Because of the rapid reinfestation process, the transmission in Argentina and Bolivia remains in the ecorregion of Gran Chaco, comprising more than 1 million km^2 (Gorla et al. 2015; Cortez et al. 2010; Gurtler 2009). Among the Latin American populations most affected by neglected diseases and Chagas disease are the indigenous communities (ONU 2008). In Paraguay, the indigenous people have a 7.9 times greater probability of being poor than the rest of the population (ONU 2008). The greatest concentration of indigenous people is in the departments of Boquerón and Presidente Hayes (44.2%) in the Central Paraguayan Chaco (Fig. 1). This proportion is high compared with the national average (1.8%) (DGEEC 2014). The region has the lowest rates of human development in the country, with poverty reflected indirectly by the low literacy rate, poor

✉ Antonieta Rojas de Arias
rojasdearias@gmail.com

[1] Center for the Development of Scientific Research (CEDIC) (FMB/Díaz Gill Laboratory Medicine), Manduvirá 635 entre 15 de agosto y O'Leary, Asunción, Paraguay

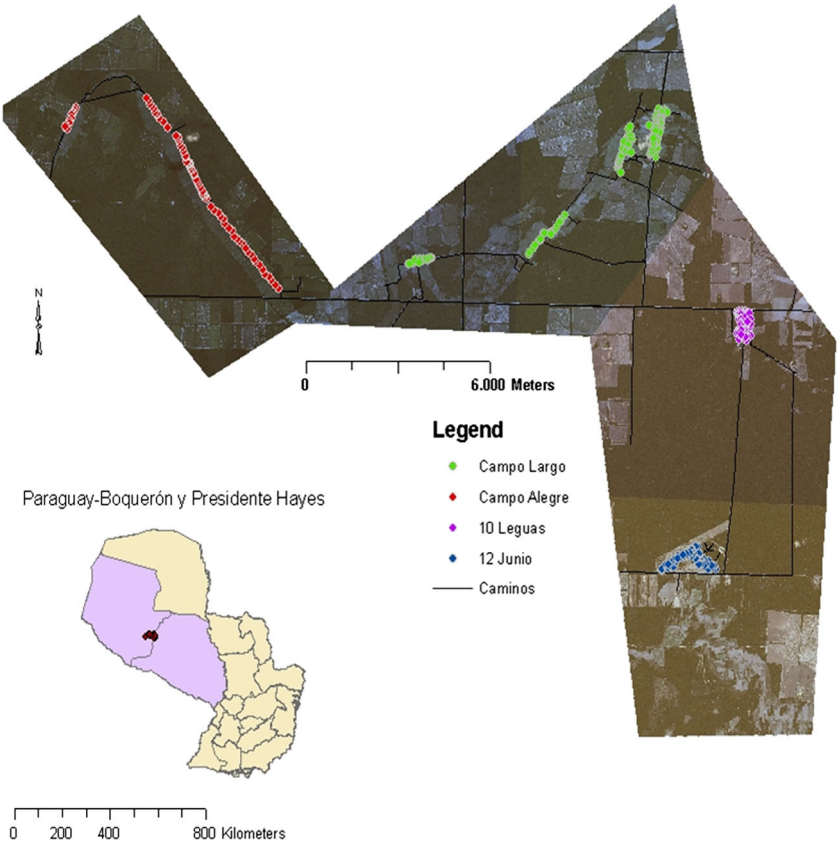

Fig. 1 Location of the indigenous localities in the Paraguayan Chaco

housing and poor access to drinking water and electricity (Fogel 2006; DGEEC 2014).

Paraguay, as a developing country with a poor population affected by Chagas disease, has allocated resources to addressing this disease aiming to reduce transmission in the three departments of the Paraguayan Chaco (PAHO 2018). For a decade now, numerous strategies have been implemented in the country to address the prevention and surveillance of Chagas disease with community involvement, and their extension to and emphasis on the Chaco area are currently being implemented (Rojas de Arias et al. 2012). Due to the geographical and environmental difficulties this area presents, the reinfestation of houses persists after the residual application of insecticides (Gürtler 2009; Vazquez-Prokopec et al. 2009; Gorla et al. 2015), favoring the potential reinitiation of transmission in this area.

There is no knowledge about the Chaco indigenous communities' perception of Chagas disease or their beliefs, attitudes and behaviors related to the vector. This information is critical to address the surveillance of the reinfestation process (Sanmartino and Crocco 2000; Sanmartino et al. 2015) and potential reinitiation of Chagas disease transmission with strategies and methodologies appropriate for the Paraguayan Chaco population.

This study is inserted within the framework of a project with an ecosystem approach to the control of Chagas disease in the Gran Chaco and describes how indigenous communities of the Paraguayan Chaco, who live under extreme poverty and triatomine reinfestation pressure, perceive Chagas disease and their behaviors, beliefs and attitudes toward this highly prevalent pathology.

Materials and methods

Study area This area belongs to the departments of Boquerón and Presidente Hayes (the Central Chaco) and includes communities of Campo Largo (Lengua ethnic group), Campo Alegre (Nivaclé ethnic group), 10 Leguas (Angaité ethnic group) and 12 de Junio (Angaité ethnic group), with a total population of 1372 people (Fig. 1). These indigenous populations increased by 2.7% during the 2002–2012 period (DGEEC 2014).

These communities are considered highly endemic for Chagas disease; their infestation rate oscillates between 25 to 70%, and infection of triatomines captured in domiciles reached a natural infection rate of 9.2% (data not shown). Agents of the National Chagas Program of Paraguay subject the houses in this area to routine insecticide applications. The area also includes a Mennonite community, a group of immigrants with the greatest productivity in the country.

Survey A household survey was carried out between 2009 and 2011 based on quantitative and qualitative instruments that were constructed by a team of professionals from the social sciences departments of Argentina, Bolivia and Paraguay and adapted to the culture of each region and country.

Population and sample The household survey covered 270 indigenous families, which comprised the study population. The families in the community doing the fieldwork at the time were part of the survey. For a social network survey, 10% of families were randomly selected from the total of respondents with the highest number of favors exchanged (mutual aid) in the household survey (i.e., 30 families in total). The qualitative sample was determined using two criteria: (1) the equal representation of people by sector of the four communities and (2) the minimum amount that each technique requires to be carried out.

Variables and instruments The quantitative variables of the household survey were classified as (1) sociodemographic characteristics, i.e., age, educational level, sex, family production for sale or trade, work of the head of household, household income, work of the spouse, remuneration for work, destination of household income and migration, (2) social networks, exchange of favors and mutual aid, sufficient income, (3) knowledge and behaviors related to Chagas disease and the vector, (4) attitudes and beliefs linked to the vector and (5) access to health services. The qualitative variables for the interviews were identification of vector presence and knowledge of Chagas disease. Another qualitative variable sought in the participatory diagnoses was the identification of health problems in the communities.

Data analysis The quantitative data were processed using Microsoft Office, Excel 2007 and SPSS v. 15.0 for Windows. The results were reported in percentages to each variable measured. The qualitative information was transcribed in digital form in Word for Microsoft Office. The interviews made in Guaraní were translated into Spanish and those in Nivaclé translated by the indigenous facilitators of each ethnic group selected for this purpose while the fieldwork was carried out. The data were organized into previously established categories of analysis.

Ethical considerations The research team made a recognition visit to each community, presenting the objectives of the research, the scope and possible benefits the people would receive from the information provided as well as the assurance that the data obtained would be treated confidentially. They were also assured that the results would be presented to the communities after the study concluded. The need for the communities to discuss their participation in the study collectively was emphasized. The *caciques* acted as representatives of

Table 1 Socioeconomic aspects and demographic characteristics of the indigenous population from 2009 to 2011

	Recorded number (%)
Age (years)	
0 to 10	262 (19)
11 to 20	337 (25)
21 to 30	181 (13)
31 to 40	163 (12)
41 to 50	110 (8)
50 or more	101 (7)
Educational level (last year or approved grade)	
Preschool until 3rd grade	438 (51)
4th to 6th grade	322 (38)
7th to 9th grade	56 (6.5)
1st to 4th grade (1st grade of high school)	14 (1.5)
Illiterate	12 (1.4)
High school graduate	1 (0.1)
Gender	
Male	715 (52)
Female	656 (48)
Family production for sale or exchange	
Yes	86 (32)
No	167 (62)
Does not answer	17 (6)
Work of head of household ($n = 270$)	
I work at a farm with Mennonites	89 (33)
Agriculture/farm/small livestock	138 (51)
Artisan/health promoter/seller/shepherd	18 (7)
Does not work	5 (2)
Tree-felling	8 (3)
Housewife	6 (2)
Does not know/does not answer	6 (2)
Consideration of household income as sufficient	
Yes	54 (20)
No	187 (70)
Does not know/does not answer	29 (10)
Work of the spouse	
Household tasks, farm, animals, home	193 (71)
Work for the Mennonites	24 (9)
Others	13 (14.3)
Does not know/does not answer	40 (14.7)
Compensation for work	
Money	178 (66)
Money and merchandise	34 (12)
Merchandise, products, services	27 (10)
Does not receive payments	24 (9)
Does not know/does not answer	7 (2)

Household survey

Table 2 Work, gender, subsistence and food consumption from 2009 to 2011

Work and gender	
Semi-structured interviews	Clear division of tasks by sex:
	Men "*work in the colonies, milk*" and perform "*tree-felling and those things*"
	The women "*work in the farm and in the garden*" and "*they stay in the house to take care of children*"
	Type of majority work carried out: "Agriculture, farm and their own livestock" are related to the availability of land for cultivation and the existence of share rent crops such as "*sesame, beans*", "*we are now preparing to plant fruits and sesame*"
Subsistence	
Focus groups	Critical situation regarding food:
	"*Sometimes we do not have breakfast, sometimes we do not have lunch, sometimes we will not even have tereré (traditional cold beverage made with yerba mate and cold water) and why is this the case?*"
	"*We indigenous people have the worst*"
	"*The need…it squeezes me, I cannot stand sometimes and I talk to my husband how about how we can get out of this*"
Consumption	
Semi-structured interviews	The income of the majority only covers food:
	It covers "*only food*" and "*sometimes it covers for something small we want to buy*"
	Goods that must be purchased: "*Meat, rice, noodles, sweet potatoes, pumpkin, fruits are not available, because they do not grow*" Hunting is no longer the main way to obtain food

Interviews and focus groups in the field

their communities throughout the research process. The Ethics Committee of the Moisés Bertoni Foundation approved the research protocol in July 2009.

Results and discussion

Socioeconomic aspects and demographic characteristics

The population studied was mostly young; a total of 44% were < 20 years of age and only 7% percent of the population was > 50 years of age. There were slightly more males (52%) than females. The number of years of formal education was very low (< 5 years), which did not allow having the skills, abilities and knowledge essential to achieve a better quality of life (Table 1).

The possibility of obtaining work within the Mennonite communities allows some of the studied indigenous communities to maintain paid work activities, mainly in agriculture and to a lesser extent livestock (Table 2). The shared rent crops where they work are oriented toward the important economic sector of the Central Chaco, and this important source of income implies in turn a dependence on the Mennonite community. The work done by women differs significantly from what was stated by the head of household, as they are mainly concentrated in activities related to the household (Tables 1 and 2).

Nearly half of the families had a member who had left their community or district to work, which implies that the possibilities for subsistence in the area are very limited. Most who emigrated were heads of households, and usually they send very little to their families (Table 3). Considering that incomes are not sufficient and that 42% of households with a member who had emigrated stopped receiving that support during each absence, this leads to a vulnerable situation if this member is the head of the household. Most people whose occupation was outside the home worked with the Mennonites in activities such as dairy farming, cultivation, tree-felling and animal care (Table 3).

Migration of household members and State support

Migratory movement was motivated by the search for work, and having insufficient income meant almost exclusively needing more for food. However, this uprooting did not necessarily culminate in obtaining sustenance for the family. State support in the form of social security, retirement and pensions is deficient. An overwhelming 87% (234) stated that they did not receive any type of retirement support or pension (Table 3). The State's presence was imperceptible and access to health services limited, although two communities (Campo Alegre and Campo Largo) had private insurance from the Mennonite Indigenous Cooperation Services Association (ASCIM).

The socioeconomic situation observed partially reaffirms the statement of Branislava Susnik (1982) that these

populations are still immersed in the struggle for survival and mainly focused on getting food, as in ancient times. There is an aggravating circumstance at present: as the natural resources are exhausted, the people do not have opportunities to find jobs.

Community social networks

The existence of social networks has alleviated the situation of poverty, since families that do not have support are alone to face adverse situations (Table 3). Solidary cooperation was a common practice between families, who shared their food, supported each other when needed with household or other tasks, and met with relatives and neighbors to share recreation times. Similar practices were found in rural areas of Argentina where networks are an established social system (Dell'Arciprete et al. 2014). The diversity of strategies adopted for subsistence revealed the adaptive capacity of these indigenous groups to the modalities of wage labor. The varied subsistence strategies of the families did not translate into sufficient income to cover their basic needs because they were short term and aimed at satisfying immediate food needs. The appropriation of natural resources in their grandparents' time has been replaced by work, and it can be considered a replacement for searching for hunting and gathering territories. Considering the perspective of Pierre Bourdieu (1999) that poverty should be considered according to both what one does not have and what one has, the existence of social networks as a set of relationships for the exchange of resources was in force in these communities to alleviate deficiencies in obtaining food.

Knowledge

The population does not have precise knowledge about Chagas disease, since less than a quarter of those interviewed consider it dangerous. The vast majority (72%) has no knowledge of it or the vector (Table 4). Chagas disease does not exist in the culture of the different ethnic groups studied. However, the vector is the only link between the indigenous population and a nonexistent disease mentioned by people outside their community. This situation has been observed in other indigenous groups of the continent (Ríos-Osorio et al. 2012). In the Yucatan Peninsula (Mexico), part of a population of Mayan natives had limited understanding of the disease (Rosecrans et al. 2014). In other studies, such as one on endemic communities in Honduras, the majority of the population knew about Chagas disease but had poor or very poor knowledge about Chagas transmission and its vectors (Donovan et al. 2014).

Table 3 Social characteristics and State support from 2009 to 2011

	Number (%)
Migration ($n = 270$)	
Yes	117 (43.3)
No	152 (56.3)
Does not know/does not answer	1 (0.4)
Family member who emigrates ($n = 117$)	
Head of household	75 (64)
Others (includes full family) (4)	40 (34)
Does not know/does not answer	2 (2)
Time of absence from home, in weeks ($n = 117$)	
1 to 4	56 (48)
5 to 20	13 (11)
> 20	42 (36)
Does not know/does not answer	6 (5)
State support ($n = 270$)	
Yes	44 (16)
No	201 (75)
Does not know/does not answer	25 (9)
Help received from relatives, friends, neighbours in the face of needs ($n = 270$)	
Always	117 (43.3)
Sometimes	93 (34.3)
Never/almost never	48 (18)
Does not know/does not answer	12 (4.4)
Aid granted in the last three months ($n = 270$)	
Yes	194 (72)
No	72 (27)
Does not know/does not answer	4 (1)
Type of aid granted ($n = 194$)	
Jobs	29 (15)
Feeding	89 (46)
Health/medications	16 (8)
Cash	8 (4)
Water supply	5 (3)
Farm	21 (11)
Various forms/in everything	24 (12)
Do not know/do not answer	2 (1)
Consideration of household income as sufficient ($n = 270$)	
Yes	54 (20)
No	187 (70)
Does not know/does not answer	29 (10)

Household survey

Attitudes

Attitudes toward the vector of Chagas disease reflect an inaccuracy in the studied indigenous people's knowledge of it. Unlike other Guaraní indigenous groups in Bolivia,

Table 4 Perception and visibility of Chagas disease from 2009 to 2011

	Number (%)
Knowledge of Chagas disease ($n = 270$)	
Disease attacks organs/dangerous	46 (17)
Vinchuca's disease/it kills	10 (4)
Flu, fever, headache or throat ache	14 (5.2)
Bug that bites/pointed/dangerous	2 (1)
Disease has to be eliminated	1 (0.4)
Chagas is not dangerous	1 (0.4)
Does not know	196 (72)
What does transmit it? ($n = 74$)	
The *vinchuca*	44 (59.4)
A bug	1 (1.4)
Dogs and mice	1 (1.4)
Chickens	1 (1.4)
By contagion, tereré (herbs with cold water), etc.	1 (1.4)
Does not know/does not answer	26 (35)
Can it be cured? ($n = 74$)	
Yes	39 (52.7)
No	31 (41.8)
Does not know/does not answer	4 (5.4)
A member of the household has suffered the disease ($n = 270$)	
Yes	41 (15)
No	200 (74)
Does not know/does not answer	29 (11)
Identification of the most annoying animals (the highest percentage) ($n = 270$)	
Mosquito	70 (26)
Chichâ guazú (Guarani word for vinchuca), vinchuca, *emascó* (Enxet word for vinchuca) Vayanahá (Nivaclé word for vinchuca)	50 (19)
Identification of the most dangerous animals ($n = 147$)	
Snake	83 (30)
Vinchuca	64 (24)
Identification of hard-to-kill animals ($n = 133$)	
Snake	86 (32)
Vinchuca	47 (17)
Recognition of the kissing bug when you see it ($n = 270$)	
Yes	234 (87)
No	31 (11)
Does not know/does not answer	5 (2)
Recognition of the most dangerous vinchucas ($n = 234$)	
Black	119 (51)
Brown	39 (16)
Red	13 (6)
Yellow	5 (2)
Other	11 (5)
Does not know/does not answer	47 (20)
Knowledge of the presence of vinchucas at home at present ($n = 270$)	
Yes	100 (37)
No	147 (54)
Does not know/does not answer	23 (9)
Presence of the vinchucas at some time in your home ($n = 270$)	
Yes	216 (80)
No	39 (14)
Does not know/does not answer	15 (6)

Household survey

who know the Chagas vector very well (Verdú and Ruiz 2003), or in Honduras, where the population clearly identified the risks (Donovan et al. 2014), the studied indigenous communities did not know Chagas disease and knew little or nothing about its vector. They believed it is curable, despite recognizing *vinchucas* and qualifying them as annoying bugs that should be removed, but they did not link them to the disease. The disease was not considered an important community problem, nor was the risk of suffering from the disease. There is undoubtedly ignorance about the treatment of the disease; however, a significant percentage of the study population trusts that the health services will know what to do and considers that there are adequate medications (Table 4).

Table 5 Identification of the vector and knowledge of the disease from 2009 to 2011

Semi-structured interviews	
Vector identification	Identification of the vector is not precise:
	"*Some had and some did not have. I do not know if it exists in the houses of material or wood. There is usually more in the wooden house, which has wood on its wall*"
	"*We live in our community without thinking that some disease or problems will arise because many times people do not realize it*"
	"*Now we are listening and we realize and other people who do not realize that, they do not even think about it*"
Focus groups	
Knowledge of the disease	Lack of precise knowledge regarding the disease and its vector:
	"*Well…talks have to be made to understand what the disease brought by this vinchuca is*"
	"*It worries me that our culture is used to having vinchuca*"
Field interviews	

Practices

Even without having clear knowledge about Chagas disease, the population has incorporated two practices to prevent it: first, to clean the houses to prevent the vector from remaining; second, to spray the houses to eliminate the *vinchucas* that are in their homes. They identified the presence of *vinchucas* in their homes and the application of insecticides ("spraying") as the main way to fight the vector. They showed no interest in adopting measures to avoid getting sick and expressed resignation or the inability to do anything about the vector. This discouragement can be related to the slim possibility of having their own means for intradomiciliary elimination. This population behavior was also observed by Dell'Arciprete et al. (2014), who showed that the rural population in northern Argentina adapted to the presence of the vector, naturalizing it, because of their ignorance about the relationship between it and the risks of contracting Chagas.

There are two practices that do not appear in this section: housing improvements—conditioned by the economic capacity—and the search for vinchuca nests in the house for their subsequent elimination (Table 4). However, housing improvement should not be expected as an exclusive strategy in the control of this disease, but as an alternative that will increase the quality of life in populations placed in areas endemic for Chagas disease (Prüss-Ustün et al. 2016).

Behaviors, attitudes and beliefs about Chagas disease

The majority declared that they worry about having *vinchucas* in their houses; however, the reasons for this concern do not refer to Chagas disease but to something that produces fear (Table 5). In almost all the questions related to the presence of the vector at home, the answers reflected a significant lack of knowledge (Table 6). The behaviors and attitudes observed in these communities are similar in other Latin American regions. The cultural component of the disease allows communities to coexist with vectors, and the biological component makes Chagas a silent and symptom-free disease (Zabala 2012).

National Chagas control program success

Despite the almost imperceptible presence of the State in the area, for many years it has promoted and reinforced the intervention of the National Chagas Program, which has reached all the villages. This program has been implementing the strategy of house chemical spraying and entomological surveillance by communities for several years (Rojas de Arias et al. 2012). The environmental conditions, residual effect of the insecticides and distances between communities in the Chaco make the implementation of this strategy difficult; however, currently the three departments of the Paraguayan Chaco have achieved the vector transmission cutoff (Rojas de Arias 2016; PAHO 2018). Therefore, the strengthening of control and surveillance actions is crucial to maintaining success, since the processes of repopulation and reinfestation are rapid in this region. Additionally, the main vector *Triatoma infestans* was found in sylvatic populations, a fact that increases the infestation pressure against domestic and peridomestic areas (Rojas de Arias 2016; Rolón et al. 2011).

The State still owes a debt because it has not fulfilled its obligation to protect the indigenous communities and focus on the access to health as a major factor in people's quality of life.

Conclusion

In summary, the precarious socioeconomic conditions of the communities studied, their limited access to health, the permanent lack of access to food that forces them to migrate and the mutual support strategies to survive as

Table 6 Behaviors, attitudes and beliefs about Chagas disease vectors from 2009 to 2011

	Number (%)
Behavior in the presence of vinchucas ($n = 211$)	
Kill them	174 (81)
Take the vinchuca and put it in a box	15 (7)
Spray it with insecticide	7 (3)
Try to kill them unsuccessfully	7 (3)
Nothing	6 (3)
Take them out of the room/house	2 (1)
Does not know/does not answer	5 (2)
Search for vinchucas in the house ($n = 270$)	
Yes	185 (69)
No	78 (29)
Does not know, does not answer	7 (2)
Do something so that there are no vinchucas in the house ($n = 270$)	
Yes	125 (46)
No	54 (20)
Does not know/does no answer	91 (34)
Act to avoid the disease ($n = 270$)	
Yes	67 (43)
No	26 (16)
Does not know/does no answer	64 (41)
Concern about the presence of vinchucas in the house ($n = 270$)	
Yes	220 (82)
No	17 (6)
Does not know/does no answer	33 (12)
Why are you worried ($n = 220$)	
Bite/makes you sick/scary	82 (37.2)
It is dangerous for people	58 (26.4)
Suck blood/it hurts	28 (13)
There may be Chagas	1 (0.4)
Others	33 (14.8)
Does not know/does not answer	18 (8.2)
Belief that it is feasible to eliminate the vinchucas forever	
Yes	115 (43)
No	91 (34)
Does not know/does no answer	64 (23)
Ways in which you can eliminate the vinchucas forever ($n = 115$)	
With fumigation/SENEPA (national vector control institution)	45 (39)
With medicines/poisons/fumigating	23 (20)
Caring for the environment/cleaning	22 (19)
Others	14 (13)
Does not know/does not answer	11 (9)
Access to health services in case of having Chagas disease ($n = 270$)	
Yes	136 (50)
No	75 (28)
Does not know/does no answer	59 (22)

Household survey

well as the limitations of communication because of the language, limited knowledge about Chagas disease and other diseases of poverty show the extreme vulnerability of these indigenous groups.

The current strategy on the prevention and surveillance of the vector transmission of Chagas disease in the region should be complemented by the improvement of housing and basic health education. All the actions carried out by the State at the community level should be focused on improving the living conditions of the indigenous population in an integrated manner. While high levels of poverty persist, efforts to maintain the recently reached reduction of transmission of Chagas disease will be huge and unsustainable.

The actions directed at the indigenous population should use intervention strategies with participatory processes in their communities, with the objectives of integrating the perspectives of the people and involving them in the actions that affect them. The design and implementation of control actions for national programs should be based on a comprehensive approach according to the rights and specific cultural characteristics of the affected populations.

Acknowledgments The authors thank the four indigenous communities of the Chaco.

The International Development Research Center (IDRC) financed the study, project no. A70596. The article was initially drafted and reviewed in the workshop of the Communicable Diseases Research Program of the Communicable Diseases and Health Analysis Department of PAHO/WHO, which supports and disseminates the eco-health approach. All authors belong to the National Program of Incentives to Researchers (PRONII in Spanish) from the CONACYT Paraguay. The authors thank to Dr. Carla Cecere by the indigenous communities map published.

Compliance with ethical standards

Conflict of interest CM Arrom Suhurt declares that she has no conflict of interest.

CH Arrom Suhurt declares that she has no conflict of interest.

MA Arrom Suhurt declares that she has no conflict of interest.

M Rolón declares that she has no conflict of interest.

MC Vega Gómez declares that she has no conflict of interest.

A Rojas de Arias declares that she has no conflict of interest.

Ethical Statement All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Informed consent Informed consent was previously obtained from all individual participants included in the study.

Ethical approval The Fundación Moisés Bertoni Ethical Committee approved the protocol of this study in July 2009.

Publisher's Note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

References

Bourdieu P (1999) La miseria del mundo. Akal, Madrid

Dell'Arciprete A, Braunstein J, Touris C, Dinardi G, Llovet I, SSosa-Estani S (2014) Cultural barriers to effective communication between Indigenous communities and health care providers in Northern Argentina: an anthropological contribution to Chagas disease prevention and control. Int J Equity Health 13:6. https://doi.org/10.1186/1475-9276-13-6

DGEEC (2014) Pueblos Indígenas en el Paraguay. Resultados Finales de Población y Viviendas 2012. III Censo Nacional de Población y Viviendas para Pueblos Indígenas. http://www.dgeec.gov.py/Publicaciones/Biblioteca/indigena2012/Pueblos%20indigenas%20en%20el%20Paraguay%20Resultados%20Finales%20de%20Poblacion%20y%20Viviendas%202012.pdf. Accessed 10 October 2018

Dias JCP (2006) The treatment of Chagas disease (South American Trypanosomiasis). Ann Intern Med 144:772–774. https://doi.org/10.7326/0003-4819-144-10-200605160-00012

Donovan SD, Stevens M, Sanogo K, Masroor N, Bearman G (2014) Knowledge and perceptions of Chagas disease in a rural Honduran community. Rural Remote Health 14(3):2845 https://www.ncbi.nlm.nih.gov/pubmed/25204581

Fogel R (2006) La Cuestión Socioambiental en el Paraguay. Centro de Estudios Rurales Interdisciplinarios (CERI), Asunción

Gorla DE, Vargas Ortiz R, Catalá SS (2015) Control of rural house infestation by *Triatoma infestans* in the Bolivian Chaco using a microencapsulated insecticide formulation. Parasit Vectors 8:255. https://doi.org/10.1186/s13071-015-0762-0

Gürtler RE (2009) Sustainability of vector control strategies in the Gran Chaco Region: current challenges and possible approaches. Mem Inst Oswaldo Cruz:52–59. https://doi.org/10.1590/S0074-02762009000900009

Cortez MR, Monteiro FA, Noireau F (2010) New insights on the spread of Triatoma infestans from Bolivia—implications for Chagas disease emergence in the southern cone. Infect Genet Evol 10:350–353

Molina I, Salvador F, Sánchez-Montalvá A (2016) Actualización en enfermedad de Chagas. Enferm Infecc Microbiol Clin 34(2):132–138. https://doi.org/10.1016/j.eimc.2015.12.008

ONU (2008) La situación de los pueblos indígenas del mundo. DPI/2551/B — 0964061 — Produced by January 2010. Accessed 28 Sept 2018

PAHO (2018) Paraguay interrupts vector transmission of Chagas in the home. https://www.paho.org/hq/index.php?option=com_content&view=article&id=14546:paraguay-logro-interrumpir-la-transmision-vectorial-domiciliaria-de-la-enfermedad-de-chagas&Itemid=135&lang=en. Accessed 28 September 2018

Prüss-Ustün A, Wolf J, Corvalán C, Neville T, Bos R, Neira M (2016) Diseases due to unhealthy environments: an updated estimate of the global burden of disease attributable to environmental determinants of health. J Public Health 39(3):464–475. https://doi.org/10.1093/pubmed/fdw085

Ríos-Osorio LA, Crespo-González JJ, Zapata-Tamayo MA (2012) Etnometodología para la comprensión y el manejo de la Enfermedad de Chagas en las poblaciones indígenas Wiwa asentadas en la vertiente suroriental de la Sierra Nevada de Santa Marta. Saude soc 21(2):446–457. https://doi.org/10.1590/S0104-12902012000200017

Rojas de Arias A (2016) La certificación del corte de transmisión vectorial del *Trypanosoma cruzi*, agente causal de la enfermedad de Chagas. Mem Inst Investig Cienc Salud 14(3):3–6. https://doi.org/10.18004/Mem.iics/1812-9528/2016.014(03)03-006

Rojas de Arias A, Abad-Franch F, Acosta N, López E, González N, Zerba E et al (2012) Post-Control Surveillance of *Triatoma infestans* and *Triatoma sordida* with chemically-baited sticky traps. PLoS Negl Trop Dis 6(9):1822. https://doi.org/10.1371/journal.pntd.0001822

Rolón M, Vega MC, Román F, Gómez A, Rojas de Arias A (2011) First report of colonies of sylvatic *Triatoma infestans* (Hemiptera: Reduviidae) in the Paraguayan Chaco, using a trained dog. PLoS Negl Trop Dis 5(5):1026. https://doi.org/10.1371/journal.pntd.0001026

Rosecrans K, Cruz-Martin G, King A, Dumonteil E (2014) Opportunities for improved Chagas disease vector control based on knowledge,

attitudes and practices of communities in the Yucatan Peninsula, Mexico. PLoS Negl Trop Dis 8(3):2763. https://doi.org/10.1371/journal.pntd.0002763

Sanmartino M, Crocco L (2000) Conocimientos sobre la enfermedad de Chagas y factores de riesgo en comunidades epidemiológicamente diferentes de Argentina. Rev Panam Salud Pública 7:173–178

Sanmartino M, Saavedra A, i Prat J, Parada Barba M, Albajar-Viñas P (2015) Que no tengan miedo de nosotros: el Chagas según los propios protagonistas. (Portuguese). Interface-Comunicação, Saúde, Educação 19(55):1063–1075. https://doi.org/10.1590/1807-57622014.1170

Susnik B (1982) El Rol de los indígenas en la formación y en la vivencia del Paraguay. Instituto Paraguayo de Estudios Nacionales. I.P.E.N., Asunción

Vazquez-Prokopec GM, Spillmann C, Zaidenberg M, Kitron U, Gürtler RE (2009) Cost-effectiveness of vector control strategies against Triatoma infestans in rural northwestern Argentina. PLoS Negl Trop Dis 3:363. https://doi.org/10.1371/journal.pntd.0000363

Verdú J, Ruiz MT (2003) Control del Chagas en comunidades guaraníes: conocimiento y hábitos higiénicos dentro del Proyecto de Mejoramiento de Viviendas en Bolivia. Gac Sanit 17(2):166–168. https://doi.org/10.1016/S0213-9111(03)71717-8

Zabala JP (2012) La enfermedad en su laberinto: avances, desafíos y paradojas de cien años del Chagas en Argentina. Salud Colectiva (online) 8(1), 9–21. http://www.scielo.org.ar/scielo.php?script=sci_arttext&pid=S1851-82652012000300002&lng=es&tlng=es. Accessed 28 September 2018

World Health Organization (2015) Chagas disease in Latin America: an epidemiological update based on 2010 estimates = Maladie de Chagas en Amérique latine: le point épidémiologique basé sur les estimations de 2010. *Weekly Epidemiological Record = Relevé épidémiologique hebdomadaire, 90* (06), 33–44. http://www.who.int/iris/handle/10665/242316. Accessed 28 September 2018