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Knowledge of triatomine insects and of the Chagas disease among people from localities which have different levels of vector infestations

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Abstract *Community participation is the main strategy to sustainability of Chagas disease entomological surveillance. The purpose of this study was to evaluate the level of knowledge on triatomine insects and Chagas disease among the residents from eight localities of Diamantina, in Minas Gerais, with a view to observing any associations between their knowledge and infestations by triatomines. In order to evaluate this knowledge, questionnaires were used containing both closed and open questions. They were applied to 583 residents who were ten years old or over. To establish if they could recognize the triatomine insect, they were given samples to look at. The responses to the closed questions were analyzed with reference to any frequencies of and associations with infestations involving this insect. The responses to the questions were organized into different thematic areas and were descriptively analyzed. Although the resident's ability to recognize the triatomine insect was not associated with the infestation of the localities, the residents in the areas that had higher infestations showed that they had a good knowledge of the available support services and the need to send the insects to them. We did not observe any associations between triatomine infestations and knowledge of Chagas disease. The results of this study can provide guidance on education that can be given by the health services to the community in order to encourage them to provide notifications of the triatomine insects.*

Key words *Knowledge, Chagas disease, Vector control*

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Introduction

Chagas disease represents an endemic and major problem for the American continent which principally affects vulnerable people that live in rural areas in substandard accommodation. Vector-borne transmission of *Trypanosoma cruzi* (Chagas 1909) is the principal route to the human infection[1]. The insect-vectors are blood-sucking hemipteransand there are 149 species of them. They belong to the Triatominae subfamily and they are popularly known in Brazil as "barbers"[2,3].

In Brazil the main method used to combat Chagas disease was through ensuring the insect was not present in people's houses. This advice was part of a national campaign launched in the 1950s. It reached all the endemic area in the mid-1980s through the Chagas disease Control Program (PCDCh) that was coordinated by the Public Health Campaigns Office (SUCAM)[4].

The PCDCh followed the model used in the Eradication of Malaria Campaign that was structured in three major phases: identifying the areas affected and obtaining information on the triatomine insect, combating the insects in people's residencies and implementing entomological surveillance and monitoring of the situation. In the first phases, the actions carried out were vertical in nature whereby pest control officers visited houses in search of the insects and applied insecticide in areas hit by the endemic. In the entomological surveillance phase, due to the low rates of household infestations, the pest control officers did not detect many insects during this phase. This therefore did not justify pest control officers being placed in hard to reach areas searching for signs of the insect as it was not cost effective. In this context, detections fell to the residents who, upon finding a suspected insect, gave it to a designated community member who was in charge of the local Triatomine insects Information Units (PIT) that were generally situated in schools, health centers or households. From the PIT the insect would be sent to the health service to be identified and examined for trypanosomatides. If it was confirmed that the insect was a triatomine, a pest control officer would be sent to the household to search for further specimens. Where such were found,both the house in question, the furniture and the surrounding buildings would be sprayed with insecticides[5-7].

Due to control and containment campaigns, the Chagas infection iscontrolledin Brazil[1]. In this context entomological surveillance with the participation of the community isrecognized as an effective and sustained way in preventing new infections, becoming more thanjust aPCDCh phase[7].

The Jequitinhonha Valley in the northeast of Minas Gerais is one of the poorest regions in Brazil. In the 20th century it was one of the areas that had the highest rates of the Chagas disease, with the triatomine insects often being found in people's households. It was also one of the first regions in the country to bring in pest control measures[7-9].

In the 1960s the National Department for Rural Endemics (DNERu) carried out disinsectization of households using insecticides. This was done by pest control officers who had been involved in the Eradication of Malaria Campaign[9,10]. In the 1970s the work fell to a consortium that included the Commission for the Development of the Jequitinhonha Valley (CODEVALE) and the Diamantina Regional Health Center. Between 1975 and 1976 the region found itself under entomological surveillance directed by rural teachers to whom information was given concerning triatomine insects. In the subsequent years, however, these combative measures were curtailed owing to the loss of executive powers of the Regional Centers and low rates of compliance by the municipalities. As a result there were new outbreaks in households of the triatomine insects resulting in insect colonies. The majorspecies were the *Panstrongylus megistus* (Burmeister 1835) and the *Triatoma infestans* (Klug 1834). This situation provided the justification for restarting intensive combative actions against the triatomine insects in the 1980s when SUCAM assumed the PCDCh in the region[7,11].

Since 1999 entomological surveillance actions against the disease in the country was the responsibility of municipalities. The procedures were for the residents to notify the pest support service (based in health centers or schools) of a suspected insect and in turn a pest control officers would visit the area where the insect was found. If further insects were subsequently found, disinsectization would occur.

The participation of the community is fundamental in controlling triatomines in households. Even though the aforementioned combative actions were successful in reducing the Chagas disease, a new problem has emerged. Young people who were not around during the previous campaigns have been experiencing difficulties in recognizing and sending off suspected insects to be analyzed[12,13].

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Health education needs to remain as an important measure to ensure continuous surveillance. Armed with the requisite knowledge, the population will be in a better position to recognize and act upon any suspicious finding[14]. Having this knowledge is just as important as having a relationship with individuals, but the people must believe in the cause, for any actions to be successful[15].

One of the major challenges in the control and containment of diseases is trying to bridge the gap (for institutions and individuals) between what is known and what is actually done, known as the *know-do gap*[16]. According to the World Health Organization[17], an important tool to bridge this knowledge-do gap is to identify what the population knows about certain topics in health. This will help to identify their weak points and gaps and in turn, the relevant scientific and technical knowledge can be passed to managers, service providers and health care users in a way so that it can be used in their daily lives[18].

Surveillance on the part of the population in looking out for the Chagas disease is of paramount importance. Under-notifications in areas that might be infested, is likely to occur where people do not have the requisite knowledge to identify the insect and to notify the health authorities who can then action the pest control officers.

Having a better understand on what people know in relation to the triatomine insects and the Chagas disease may contribute to guiding actions in health care with a view to strengthening community participation around surveillance. This study aimed to evaluate the level of knowledge of the residents in infested areas in Diamantina which is in the Alto Valley region of Jequitinhonha in Minas Gerais. This region is endemic with Chagas disease.

Methods

The study took place in the urban and rural areas in the municipality of Diamantina situated in the Jequitinhonha Valley region in the northeast state of Minas Gerais. In 2014 it had an estimated population of 47,803 inhabitants covering an area of 3.891,659 km² with 333localities in 25 urban neighborhoods which includes the main urban nucleus. There were 308 communities located in the other parts of the municipality(rural areas). The urban population represented approximately 87% of the total population[19].

According to the National Serological Inquiry carried out in the 1980s, the municipality of Diamantina was found to be serologically positive for *T. cruzi* for 11.7% of the population, which surpassed the state average in Minas Gerais and in Brazil which was 8.8% and 4.2% respectively[20].

In order to identify the areas to be studied, some criteria was developed in which all of the areas were grouped into four categories based of the number of triatomine insects that were captured in households through notifications given and personnel being sent to areas. This covered 2001 to 2011 becausethe detailed entomological information during this period was available.

The categories were: areas with no infestations (the absence of the triatomine insects during the given period), low infestation areas (corresponding to a tertile with fewer numbers of triatomine insects - from one to five), moderate infestation (corresponding to the second tertile - between six and 41 insects) and high levels of infestation (corresponding to the tertile in areas with the highest numbers of triatomine insects - between 42 and 124 insects). Two localitiesfor each category were chosen. One belonged to the urban nucleus in the main part of the municipality (the main borough) and the other was outside of this area (in a rural area). This was based on the divisions identified by the National Health Foundation[21]. Due to questions of logistics and access issues, random selections were done amongst the localities that met the criteria in being a maximum of 40 km from the city urban nucleus. They needed to have been similar with reference to grassland and vegetation (about 1000m above sea level and vegetation being predominate in rocky fields). We opted to draw lots again in areas borderingother that had been randomly chosen before.

The following were the chosen areas with their respective populations based on data from the Local Authority of Diamantina: Serrano neighborhood (291 inhabitants) and Bandeirinha Farm (58) areas without infestation, Santo Inácio neighborhood (547) and Village of the Vau (101) low infestation areas, Gruta de Lourdes neighborhood (328) and Village of the Quartel do Indaiá (105) moderate levels of infestation, Cidade Nova neighborhood (1298) and Village of Extração (268) as boroughs with the highest levels of infestation. The available data on the size of the populations dates back to 2003, owing to the lack of updates registered by the local authority.

Urban areas in this study were included because triatomine infestations have been occur-

ring often at the headquarters of the municipality in Diamantina,mainly in the peripheral areas of the city. This was despite the fact that infestations were traditionally connected with semi-rural areas.

Questionnaires were used based on the models of Silveira et al.[12] and Villela et al.[13] in order to understand the population's knowledge of the *T. cruzi* and the Chagas disease. It had twelve multiple choice questions and two questions that required a written response.

The multiple choice questions covered the following: knowledge on what to do concerning triatomine insects, whether the resident could recognize the insect when amongst others, if the resident had seen one triatominebefore, whether the interviewee or a relative had been bitten by one, what to do if one was found, if it could transmit a disease and if so what. In relation to the Chagas disease, the questions covered: whether the person had heard about the disease before, what organs may be affected, if someone they knew had the disease, if they knew where to take the insects and whether there were health facilities in their municipality to combat this disease. The questions requiring written answers covered: what to do to avoid the insect in households and whether the resident would like to give some suggestions to the pest control service on the Chagas disease in the municipality.

We showed samples of Hemiptera (an adult predator and an adult and one nymph *P. megistus,*also a *Rhodnius neglectus* adult Lent 1954 and a nymph specie and one Phytophagous Hemiptera) to assess their ability to recognize the triatomine insects at the beginning of the questionnaire. The resident had to point out which insects were the triatomine insects. When the person successfully pointed out which was the triatomine insect, we considered that to be the requisite knowledge in accordance with Villelaet al.[13].

The interviewees were adults and children from the age of ten years old and over. They were interviewed by two interviewers that went from door to door in areas covering, objectively, the largest amount of houses possible in a given area in all of the houses where individuals wanted to participate in the study. When a minor opened the door, they were only allowed to participate after consent was obtained from someone responsible for them, such as a parent. There was a significant sample of 583 people from whom data was collected between December 2011 and September 2013, with a significance level of 0.05.

We decided to include children as we noticed before that young people had difficulties in recognizing triatomine insects when compared with adults. This may be due to a lack of general awareness in the scenario of controlled transmission of the Chagas disease[12,13].

The residents got together to discuss the triatomine insects and its role in spreading the Chagas disease, after the questions were answered. They also talked about the importance of participation in detecting and taking captured insects to the municipal health services.

The Ethics Committee for Research at the Federal University of Vales do Jequitinhonha and Mucuri approved this study in compliance with resolution 196/96 from the National Council for Health. Participation in the research was based on the condition of individuals signing a consent form. For those under 18 a signature was required from a parent or legal guardian.

The responses were tabulated in the Epi Info™ program version 3.5.4[22]. The multiple choice questions were analyzed with reference to the frequency of which the alternatives were chosen. They were analyzed in relation to associations with different categories of infestations in areas. The ability to recognize triatomine insects was also analyzed with reference to the age group of the participants and the residency zone. The age groups were divided between those being less than or equal to 25 years old and the over 25s. This was adopted owing to the period of birth for those whose ages corresponded with phases when the transmission of the Chagas infection and disease was controlled in a region. BioEstat5.0[23], was used to conduct statistical analysis, with the χtest at the significance level of 0.05. The questions requiring written responses were categorized according to themes that came out of the responses from the interviewees. After categorization was done, we analyzed the frequency of the responses corresponding to every theme in a descriptive way.

Results

583 residents were interviewed (215 were male and 368 were female) in 288 urban areas and 195 in rural areas in the municipality. The following are the number of interviewees per infested area: 81 (without infestation), 105 (low infestation), 141 (moderate infestation) and 256 (high infestation). The following were the average ages: 39.16 (deviation from the norm: ± 17.22), 41.17 (± 19.08), 39.03 (± 20.60) and 40.52 (± 19.50) years, respectively. There were 77 interviewees under the age of 18 years old.

No associations were found between the number of interviewees that could recognize the triatomine insects and infestation categories in the area where they lived. Also upon showing them the Hemiptera samples, 76.50% correctly recognized the triatomine insects. There were no statistically significant associations between the proportion of correct answers and the areas of infestations (Table 1). In relation to age groups, there were no statistically significant associations for those that got the right answers and between the interviewees under the age of 25 and those who were 25 years old or over ($\chi = 1.692$, $p = 0.2280$). However when compared to the residency zones the proportion of right answers was higher for the residents of the rural zones (85.13%) than those in the urban areas (71.91%) ($\chi = 12.555$, $p = 0.0006$).

The adult *P. megistus* was the triatomine insect that was identified the most (381 times). The second was the nymph of the same species (95 times). The *R. neglectus* was pointed out 76 times.

71.36% (416) said that they had previously seen triatomine insects. The proportion was different according to the infestation of theareas (Table 1). Houses were cited as places where the insects could be found (43.2%). Then suburban areas where people worked such as miner camp, forests and farm lands (19.13%) were mentioned and finally around health services (7.52%).

There was a significant statistically association between the rate of infestations and resident's behavior, when we evaluated conduct adopted upon finding a triatomine insect. Residents in areas with moderate to high levels of infestation would collect and take the insect to the relevant body. This was not the case for areas with low or no infestations. When questioned on the existence of places where the insect could be taken to, the higher proportion of people responded affirmatively as higher was the infestation in an area (Table 1). Also health services and schools were mainly identified as well as rural areas that had Triatomine insects Information Units (Table 2).

25.04% (146) said that they knew someone that had been bitten by the insect. The majority of them were from areas that did not have an infestation. 92.11% (537) interviewees stated that the insect could transmit a disease, with 83.71 % (488) specifically mentioning Chagas disease. There were no associations between these responses and infestations in the areas. The following are other diseases that were mentioned: yellow fever (2.06%), schistosomiasis(0.86%), dengue fever (0.86%), black fever (0.52%), malaria (0.52%), cancer (0.17%) and tuberculosis (0.17%). The last three were not placed on the questionnaire as alternatives (Table 1).

59.18% (345) said they knew someone who had Chagas disease. 50.69% of them (183/361) said they were either friends or acquaintances. Amongst family members, parents accounted for 11.36% of responses, followed by 6.37% (23) for grandparents, then 5.26% (19) being siblings and 23.55% (85) that included other family members. 10 people (2.77%) said they had the infection.

In relation to the organs that can be affected by the disease, the heart was mentioned in 72.96% of the time (394/540). This was followed by the liver at 6.30% (34). Then it was the lungs by 5.93% (32) and the kidneys by 3.33% (18). Finally the intestine was cited at 2.59% (14) and the esophagus at 1.67% (9). These were the alternatives in the questionnaire. Other options given by the residents included: blood, head, eyes, legs, skin, muscle, back, chest, nervous system and spleen representing 7.22% (39) of the indications given. 93 did not know or did not want to answer to the question, even after reading the available options. 20 of them were minors who were under 18 years old.

Cleaning and better organization in one's house were mentioned, being the overwhelming measures residents could do to prevent the insect living in their houses (Table 3).

In relation to having aid services to control the Chagas disease in the municipality, 39.62% (231) agreed with having this service. The proportional majority of these respondents were associated with areas that had moderate to high levels of triatomine infestations (Table 1). It was optional for the residents to give suggestions to the control services. 241 suggestions were given. See Table 4.

Discussion

The current main strategy for controlling the transmission of the Chagas disease is through entomological surveillance. The population contributes in a constructive way in detecting and providing notification of the triatomine insect[24,25].

A false idea of the eradication of Chagas disease came about when Brazil met its goal of eliminating the transmission of the *T. cruzi*by the triatomine *T. infestans* (anallochthonousinsect species, which was the main vector of the parasite). Alongside this, the resurgence of other more

Table 1. Knowledge and attitudes concerning triatomine insects and the Chagas disease amongst residents in areas with different levels of household insect-vector infestations. Diamantina, Minas Gerais, Brazil.

Questions related to to the triatomine insect and Chagas disease	Areas identified with infestations of the triatomine insect									
	Without infestation		Low infestation		Moderate infestation		High infestation			
	n	%	n	%	n	%	n	%	x^2	p-valor
Acknowledgement of knowing the triatomine insect									4.72	0.1933
Yes	50	61.73	56	53.33	79	56.03	164	64.06		
No	31	38.27	49	46.67	62	43.97	92	35.94		
Recognizing the triatomine insect									4.23	0.2375
Correctly	61	75.31	76	72.38	103	73.05	206	80.47		
Incorrectly	20	24.69	29	27.62	38	26.95	50	19.53		
Had already seen the triatomine insect									15.56	0.0014
Yes	61	75.31	63	60.00	92	65.25	200	78.13		
No	20	24.69	42	40.00	49	34.75	56	21.88		
Behavior adopted in case the triatomine insect was found									18.47	0.0004
Adequate (take the insect to the relevant authorities)	30	37.04	41	39.05	82	58.16	145	56.64		
Inadequate (kill it or take it incorrectly) or do not know	51	62.96	64	60.95	59	41.84	111	43.36		
Are there places where the insect can be taken to in the region?									41.50	< 0.0001
Yes	43	53.09	63	60.00	110	78.01	208	81.25		
No	15	18.52	11	10.48	5	3.55	16	6.25		
Do not know	23	28.40	31	29.52	26	18.44	32	12.50		
Do you know someone that has been bitten by the triatomine insect?									31.96	< 0.0001
Yes	30	37.04	24	22.86	20	14.18	72	28.13		
No	49	60.49	71	67.62	94	66.67	166	64.84		
Do not know	2	2.47	10	9.52	27	19.15	18	7.03		
Does the the triatomine insect transmit any diseases?									4.28	0.2331
Yes	78	96.30	99	94.29	126	89.36	234	91.41		
No	3	3.70	6	5.71	15	10.64	22	8.59		
What is the name of the disease that the triatomine insect transmits?									5.04[a]	0.1686[a]
Chagas disease	68	83.95	93	87.74	111	77.62	216	84.38		
Others[*]	6	7.41	3	2.83	9	6.29	12	4.69		
Do not know or did not respond	7	8.64	10	9.43	23	16.08	28	10.94		
Are there any prevention and control services for the Chagas disease in your region?									18.08	0.0004
Yes	26	32.10	31	29.52	48	34.04	126	49.22		
No	55	67.90	74	70.48	93	65.96	130	50.78		

[a] grouped in categories "other disease" and do not know or did not respond". Yellow fever, Dengue fever, Schistosomiasis, Black fever, Malaria, Cancer, Tuberculosis.

visible illnesses such as dengue fever, contributed to the diminishing of the triatomine control in many of endemic municipalities[26,27].

The results show that there was an ability to recognize the triatomine insect in different municipalities in Diamantina irrespective of whether there was any history of infestations or the age group of the interviewees. In other studies (such as Silveira et al.[12] and Villela et al.[13]) the young people were not able to recognize the insect-vectors as adults in Mambaí and Buritinópolis (Goiás), and in Bambuí (Minas Gerais) respectively. The difference in the data from the journals and our study is that in this study we considered young people as anyone aged 25 or younger, whilst in overly mentioned studies they worked

Table 2. Places where residents can take the triatomine insects according to the level of household infestations by these insects in a particular area. Diamantina, Minas Gerais, Brazil.

Designated place where the triatomine insect can be taken to	Category of household infestation							
	Without infestation		Low infestation		Moderate infestation		High infestation	
	n	%	n	%	n	%	n	%
Schools	0	0	0	0	26	23.42	1	0.50
Health service centers	15	34.88	21	32.81	46	41.44	109	54.23
The Municipal Secretariat for Health	7	16.28	14	21.88	26	23.42	47	23.38
Centers for Controling the Transmission of Zoonosis	12	27.91	20	31.25	4	3.60	30	14.93
Regional Health Coordinating Authority	3	6.98	2	3.13	1	0.90	5	2.49
Sanitation Monitoring	2	4.65	0	0	0	0	2	1.00
Others*	1	2.33	6	9.38	4	3.60	6	2.99
Do not know, but know that they exist	3	6.98	1	1.56	4	3.60	1	0.50

* Social Assistant Services, Fire Service, Health Ministry, Laboratories, Universities, State Institute for Forests, Secretary for the Environment, the house of someone that works for the Municipal Secretary for Toursim.

Table 3. Behavior taken to avoid having the insects in your house by residents in areas with different levels of household infestations. Diamantina, Minas Gerais, Brazil.

Behavior taken to avoid having the insects in your house	Category of household infestation							
	Without infestation		Low infestation		Moderate infestation		High infestation	
	n	%	n	%	n	%	n	%
Cleaning and putting your house in order	35	30.43	55	38.73	81	28.62	98	36.84
Looking after the chicken pen and other similar areas	17	14.78	13	9.15	42	14.84	46	17.29
The use of insecticides	13	11.30	15	10.56	26	9.19	19	7.14
Boardering up cracks and holes and clearing away rubble (places where the insect can hide)	33	28.70	34	23.94	64	22.61	48	18.05
Check and clean beds and mattresses	0	0	2	1.41	14	4.95	15	5.64
Others*	5	4.35	7	4.93	23	8.13	15	5.64
Do not know	12	10.43	16	11.27	34	12.01	25	9.40

* "Avoid the placing of certain plants near to houses (Advocado trees, Banana trees, Brambles). Avoid leaving out standing water (water tanks, tyres, and bottles). Kill and capture the insect. Ensure the area is kept clean. Keep a watchful eye on your the state of one's house. Put up insect prevention nets on the windows. Avoid hanging up clothes on doors. Keep the house closed. Avoid keeping lights on. Burn rubbish. Allow health care workers to visit one's house. Put cloths under the doors. Paint the house white. Do not allow for the accumulation of mud near doors. Do not throw rubbish in the street."

Table 4. Suggestions given to the Control and Prevention of Chagas disease service by residents in areas with different levels of household infestations. Diamantina, Minas Gerais, Brazil.

Suggestions	Category of household infestation							
	Without infestation		Low infestation		Moderate infestation		High infestation	
	n	%	n	%	n	%	n	%
An increase in visits by health agents	16	55.17	12	38.71	21	42.86	45	34.09
Continuing combative actions and the use of insecticide sprays	1	3.45	2	6.45	6	12.24	15	11.36
Bringing information	5	17.24	7	22.58	2	4.08	13	9.85
Cleaning activities (clearing out weeds and rubbish)	2	6.90	1	3.23	0	0	5	3.79
Others*	2	6.90	0	0	3	6.12	4	3.03
None	3	10.34	9	29.03	17	34.69	50	37.88

* "Making the whole of the health service better. Finding a vacine to stop being infected. Supporting and giving value through better salaries and working conditions for those that work in pest control. Eveyones does their part to tackle this problem. Brining in doctors. The mayor paying more attetion to the residents needs. Having a place to take the triatomine insects. Instaling sewers, gutters and municipal draining sytems for the population. Put pressure on the residents to do more."

with younger age groups. Other possible reason why many young people did not recognize the insects is perhaps because control measures *T. infestans* was eliminated from those areas and due to regional environment changes[28], intra-household infestations by native species is very low. These changes made it so that many young people were not able to recognize the insect. On the other hand in Diamantina, there was a need for residents to be able to recognize the insect because infestations were recurrent in houses. This favored the ability on the part of the resident to recognize the insect, which particularly goes for the young people. This is one of the possibilities that should be considered.

Residents in rural areas were better at identifying the insect. This may be due to a greater awareness of Chagas amongst rural populations where actions taken against the insect-vector are common because the transmission of the disease in these areaswas morefrequent. Growing reports of sightings of the triatomine insects in the city of Diamantina and other regions in Brazil and Latin America highlights the importance of dealing with this issue in context[29-31].

Different to having the ability to recognize the triatomine insect, we saw associations between resident's attitudes and household infestations. Residents living in areas with high levels of infestations stated on a more frequent basis that insects should be sent to pest control services. They were also more informed of the existence of pest control services in the municipality.

Despite the knowledge and attitudes of the residents may not precisely reflect what they do in practice in relation to the triatomine insect,one should not discard the possibility of household infestations may beunder-notified in areas where residents stated that they would kill or would not send the triatomine insect to pest control services. This situation originates concern because residents in areas that did not have infestations or the infestations were considered low, stated that they had seen the triatomine insect in their own home or someone else's. This observation shows the need for more information on the correct way to take these insects to the relevant bodies. Without this, the above mentioned areas will have under-notifications. In areas where there were no people that made notifications, the support services were not actioned and no pest control actions were taken. According to Dias and Garcia[32], help given by pest control services contributes towards raising community motivation in making notifications and to participate actively in monitoring the insect-vectors that cause the infections.

Bringing people together from the community to get involved in entomological surveillance can stimulate adherence to preventive actions. In Arequipa in Peru, it was noted by Buttenheim et al.[33] that there was more participation from people in control campaigns against triatomine insects when their neighbors accepted to participate in control activities. It was less amongst neighbors that refused to do preventive actions. They believed that this gave rise to a type of contagious community participation.

Just as what had been observed in the state of Minas Gerais by Villela et al.[13], the main triatomine insect identified by the population was the adult *P. megistus.* According to the authors, this relates to the epidemiological importance of this species in the local context and the emphasis placed on its image in materials published by the health authorities. There are similarities in this study to others. *P. megistus* is the main specie that was captured in the municipality of Diamantina at the initial phase of the PCDCh[11]. The observation is reinforced in studies that demonstrate that the most common detections by residents was of adults while the nymphs were principally found during the search work done by the pest control officers[24,25].

The fact that the Jequitinhonha Valley have a high prevalence of the human infection by the *T. cruzi* parasite leading to chronic[34,35] Chagas disease, may be reflected in the large proportion of people that stated that they knew someone that had been bitten by triatomine and they knew someone that had the disease. Having Chagas disease can also may be stigmatizing[36]. This was noted, even though in an unintentional manner, where interviewees used the term "acquaintance" to refer to someone that had the illness.

Chagasiccardiomyopathy is the symptomatic clinical illness whose development is most common in the chronic phase of Chagas disease in Brazil[37]. It was particularly prominent in the Jequitinhonha Valley attacking between 42.7% to 55.7% who were infected according to studies carried out in the municipalities of Virgem da Lapa[34] and Berilo[35] respectively. The importance of this clinical state may explain the large proportion of people thatanswered the heart is the organ affected by Chagas disease. This was also observed in other areas of Brazil[12,13,38].

In studies developed by Villelaet al.[13] and Maeda and Gurgel-Gonçalves[38], in Minas Gerais and in the Federal District, respectively, general

household cleaning followed by the use of insecticides was mentioned as the main actions used to combat triatomine insects. In this study the cleaning of houses was most frequently mentioned whilst the use of insecticides was in fourth place amongst the responses given. This may be related to the differences in the species of triatomine insects found in households in the regions[25]. The use of insecticides in Diamantina is not done regularly by pest control officers because the most common species of insect found in this region does not breed and spread much, even when the officers receive notifications from the residents. This may downgrade the importance of this measure in the eyes of the population[11].

An increase in the number of house calls made by pest control officers was the main suggestion for improvements given by residents. This harkens back to an innate need for external support and top down actions, reminiscent of the initial phases of the PCDCh. It may also highlight the weakness in public services, as areas with low demands can spend long periods of time without any official municipal aid to tackle Chagas disease. These suggestions focus on actions to provide services for the residents. The population often does not recognize that they are co-participants in the process of entomological surveillance.

Based on the above perspective, the guidance concerning surveillance in the state of Minas Gerais advocates for active searches of the triatomine insects to be done in all households covering a certain percentage of areas in municipalities in the state region.This being made obligatory only occurred in the second half of 2014 when insect-vector control became one of the priorities under the responsibility of the environmental monitoring officers. The municipality of Diamantina switched to coordinating these activities which was scheduled to cover 20% of its region every year[39]. The adoption of this integrated model between the services provided and the residents will help in filling the gaps identified in this study. This will encourage the population to become more involved in collective actions in relation to entomological surveillance on the Chagas disease, particularly in dormant regions.

Making the leap between scientific knowledge and its application in practice in health care, has been a major challenge for controlling vector-borne diseases like Chagas disease, dengue fever and leishmaniasis. Participation from the community is essential in order to ensure that there is continuous entomological surveillance of Chagas disease in the context of decentralized actions[40]. In this way research that identifies areas of need has aided in the development of actions in health care, extending its reach and getting the most out of the population.

Contributors

JVL Dias participated in: the development of the initial idea, the collection of data, statistical analysis, drafting and the revision of the manuscript. DRM Queiroz participated in: the collection and analyzing of data, the productions of drafts and the revision of the manuscript. L Diotaiuti participated in: the development of the initial idea for this paper, the analysis of the data, producing drafts and the revision of the manuscript. HHR Pires participated in: the initial development of the idea for this paper, the collection and analysis of the data, drafting and final revision of this paper.

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