

CHAGAS DISEASE CONTROL VIA HOUSING IMPROVEMENT IN PARAGUAY

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INTRODUCTION

Chagas disease is widely distributed in America, from the South of USA to the South of Argentina. The prevalence varies from 5% to 60% (1-2). In a population of 360 million people living in endemic countries, 90 millions are exposed to the risk of acquiring the disease and 16 to 18 millions are infected (2). In Paraguay, *T. cruzi* infection and its main vector, *Triatoma infestans*, are widely distributed. Prevalence of infestation oscillates between 11% and 60% in the Eastern region of Paraguay (3-5). However, serological surveys showed the highest rate of infection (72%) in native groups in the Western region (6). Studies performed in Paraguay between 1983 and 1986 by the National Malaria Eradication Service (NMES) from the Ministry of Public Health and Social Welfare revealed rates of domiciliary triatomine infestation and *T. cruzi* human infection of 14% and 20%, respectively (7). A similar serological survey performed by the Institute of Health Sciences Research (IHSR), in highly endemic areas of the Eastern region of Paraguay in 1986, showed a prevalence of 22% in a representative sample of 1,601 subjects (8). Currently, in Paraguay the Chagas disease control program is being carried out at national level. Nevertheless, in previous years only small-scale sprayings have been performed in isolated areas, but nor systematic control work neither post-spraying evaluations have been made. Although several regional follow-up studies on different triatomine control interventions have been mentioned above, none of them has compared vector control interventions simultaneously in order to extrapolate their impacts on triatomine populations.

Considering the importance of this disease, a multidisciplinary project was elaborated by the Appropriate Technology Center (ATC) from the Catholic University and the Institute of Health Sciences Research (IHSR)

from the Asunción National University with the support of the International Development Research Center (IDRC). It was attempted to determine the effectiveness of three intervention methods for the Chagas disease control in rural areas, namely insecticide application, housing improvement, and a combined treatment of insecticide and housing improvement. The results of each intervention were evaluated through the measurement of the triatomine infestation of the houses and the serological evidence of *T. cruzi* human infection. Also, the degree and nature of the community participation was documented.

METHODOLOGY

The project was designed to compare pre and post-interventions in three communities. Two dependent variables were considered: 1) the level of *T. cruzi* infection in the populations, and 2) the level of the house triatomine infestation. The independent variables was the type of intervention, in three modalities: house improvement; insecticide application action and combined insecticide/house improvement action. The project was divided into 4 phases of activity. Although there was some overlapping, each phase initiated a distinct set of activities described in general terms as follows:

Phase I: It provided a pre-intervention data base describing the health, social and shelter characterization. (3 months).

Phase II: It initiated the intervention process by starting education/community participation activities in each community. In order to stimulate community interest in the interventions, demonstrations of these activities were performed. As well as setting up the intervention method of the education/community participation, this phase also initiated a triatomine-monitoring program in each community (3 months). The general health education component offered information and orientation on basic sanitary conditions. The Chagas disease component imparted knowledge of the disease and as a consequence tries to change attitudes towards Chagas. The final aim was to encourage behaviour conducive to participatory action in the triatomine monitoring and specific intervention programs.

Phase III: It was dedicated to carry out a specific intervention in each of the three selected communities over a 21-month period.

Phase IV: It was focused on the post-intervention evaluation in each community and resulting data analysis (9 months).

COMMUNITY AND ENVIRONMENT PROFILE

In the first three months of the project each of the selected communities will be described in cultural, demographic, economic, occupational and educational terms. A questionnaire covering the assessment of demographic characteristics, disease knowledge, attitudes and behaviour towards vector, time use patterns environment (domestic and peridomestic) and sanitary conditions were carried out.

BASELINE

Inhabitant census and sample collection. Previous a free and informed consent, blood samples were collected from each inhabitant older than 6 months of age, by digital puncture. Blood was collected on filter. **Evaluation of the seropositivity for *T. cruzi* infection** was performed by enzyme-linked immunoassay (ELISA) and indirect immunofluorescence (IIF). Names, surnames, age, sex and time of residence of the dwellings permanent residents were obtained from each family head.

Triatomine survey. Two trained technicians in both domestic and peridomestic environments performed baseline evaluation of house triatomine infestation of the houses. It was recorded the presence of either live or dead triatomines, either adults or nymphs, fertile eggs and/or fresh faeces, in order to certify active infestation. The presence of vestiges, as hatched eggs and dry faeces, was also recorded. Post-fumigation survey was performed every six months during two years, by active search conducted by trained personnel, detecting faeces in a calendar attached to the inner wall of the houses, and examining the insects collected by the inhabitants in plastic bags.

INTERVENTIONS

Insecticide application program. An insecticide application program was the intervention in Cañada. Lambdacyhalothrin (WHO 3021) was used in a wettable powder formulation, Icon WP10 (ICI currently Zeneca, Brazil). The field application procedure was previously published (9).

Housing improvement program. Ñanduá participated in the housing improvement program intervention. The specific intervention included the improvement of each house in the community by using the existing structures and modifying them with materials in such a way as to ensure smooth, flat and crack-free walls and ceiling surfaces and improving openings for ventilation and illumination (10). Housing improvement was discussed with each family in particular, including the terms of participation of the family members.

Housing improvement program including one-time insecticide application. In Ypaú, a combined approach was performed. Each family head agreed with the project members the improvement extension as well as the conditions following the same procedure of the other locality. They were informed that the intervention included an insecticide spraying prior to the house improvement and their permission to perform the spraying was requested. The spraying was performed not more than a month prior to housing improvement activities in each house.

Post-intervention period. In a community where insecticide spraying was the only intervention, this period was as long as 21 months. After a period of at least 3 months during which time no intervention occurred, serodiagnosis, vector density and triatomine infection rate were determined in the same way as it was done in the pre-intervention baseline data.

RESULTS

The intervention of fumigation covered 88% of the houses in Cañada and it was finished in less than one week. Housing improvement in Ñanduá had the highest coverage (90%), but it took a longer period (21 months). In Ypaú where housing improvement was preceded by fumigation in only those houses to be improved, the coverage was the lowest (67%) and it was achieved in a quite long period (36 months). The houses in the three communities were quite similar, with thatched roofs and wall of brick most of them without plaster or mud.

Triatomine infestation

One hundred and eighty two dwellings were evaluated in the initial study of the three communities. In the pre-intervention stage, based on the domiciliary presence of live triatomines in any of their stages, embryonic eggs or fresh faeces detected by the research team, high triatomine infestation percentages were found, oscillating between 33 and 49%. Peridomiciliary infestation, including triatomine presence or vestiges, was low in the communities oscillating between 3% and 27%. The three different interventive procedures were effective in terms of reduction of the vector of Chagas disease. Domiciliary and peridomiciliary infestation rates exhibited dramatic changes after the interventions. In Ñanduá (improved), Ypaú (sprayed + improved) and Cañada (sprayed) the infestation rates for the domestic environment changed from 32.8% to 3.4%, 48.6% to 16.4% and 45.1% to 2.4%, respectively. In all cases the differences were statistically significant. The most effective intervention in terms of triatomine infestation reduction, in a short-term evaluation period, was the fumigation with insecticide, achieving an about 19 fold reduction of the baseline infestation with a control impact of 97.6% (40/41). If only intervened houses were considered, the reduction of triatomine infestation was 100% in Ypaú where the combined intervention was performed (47/47), while in Ñanduá (only improved) the impact reached 96.4% (53/55). Triatomine infestation showed that although initially low triatomine densities were found, colonisation and triatomine infection indexes were high. This led us to determine that Ypaú (combined intervention) and Cañada (sprayed) showed the highest risk of *T. cruzi* transmission. Nevertheless, although Ñanduá (improved) showed a low colonisation percentage, over 10% of triatomines captured were infected by *T. cruzi*. However, in the post-

intervention period none of the triatomine captured was found naturally infected and no intervened house was colonised. The infestation follow-up performed in the houses 18 months after intervention, showed that infestation of improved or sprayed houses was less than 10%. The most sensitive test to detect triatomines after the improvement interventions was the search performed through inhabitants participation at the beginning of the process when it was compared with the one hour /man sampling test

Serological evaluation.

One hundred and forty nine (19.6%) individuals from a total of 762 people studied showed positive serology for *T. cruzi* infection in the three communities at the baseline. Positive cases were found in all age groups in the three communities. Comparison of seropositivity adjusted to age did not show any significant difference among the three populations. However, the distribution of positive cases showed different tendencies in the three communities. The highest number of positive cases was observed in the strata of 5 to 9 and 15 to 19 years in Ñanduá (sprayed). In Ypaú (combined), positive cases were more homogeneously distributed and most of them were between 5 to 9 and 60 to 64 strata. In Cañada (sprayed), positive cases showed a bimodal distribution with an important number of cases in the stratum of 25 to 29 years and between 60 to 64 and 75 to 79 strata.

The second serologic evaluation repeated 21 months later in 621 people, showed that 96 (15.5%) had positive serology for *T. cruzi* infection in the three communities. Comparison of the seropositivity rates adjusted to age showed no significant differences among the communities in the post-intervention period. Concerning sex and infection, distribution of positive cases was generally homogeneous in the three communities in pre and post-intervention periods. However, in Cañada 56% of the women were serologically positive while men showed only a 30% of positive cases. It is interesting to note a remarkable tendency of women to present a higher rate of infection in this community. The seroconversion rate was 0.5% in the three communities (3 new cases), being attributable to three cases of seroconversion (1.5%) observed in Ñanduá and no seroconversion cases were observed in both, Ypaú (combined) and Cañada (sprayed).

DISCUSSION

Even considering that interventions were not performed in all the houses in each community, there was observed a remarkable impact in both entomological and serological parameters of Chagas disease. Thus, the three tested modalities-spraying, housing improvement and the combined intervention- resulted effective for the reduction of the infestation in a short period of time. Insecticide spraying achieved the more drastic impact among control modalities on domiciliary infestation, when compared in the whole communities. Nevertheless, on a community-based comparison, fumigation was 2-fold more effective than housing improvement interventions, but when it was combined with housing improvement resulted the most effective control modality on an intervened house-based comparison. The time framework associated to the performance of the interventions should also be considered. Fumigation was performed in a short period of time, but housing improvement demanded several months to be accomplished. Fumigation was performed early in the intervention period, enhancing the possibility of having a demonstrable effect in the other two communities where the presence of the research team was more frequent. These factors along with the coverage of the intervention in the different communities could explain the reinfestation process. For instance, the combined intervention composed of domiciliary and peridomiciliary spraying before improvement guaranteed the control during a 21 month-follow-up period. The sprayed locality had a reinfestation rate of only 2.4% at month 21, probably due to the poor surveillance system or failures in the spraying process. Nevertheless, the dose utilised in the fumigation (31.5-mg ai/m²) of the sprayed village was enough to keep houses free of triatomines up to 21 months after spraying (9)

Concerning the vector surveillance, the manual sampling showed a low sensitivity when compared with the detection of calendars and the capture performed by the occupants. Besides, manual sampling is an expensive system due to the transport cost and the necessity of trained personnel. The results obtained in this study are supported by other entomological works where triatomine density was low making very difficult the triatomine captures in short visits (12). The use of calendars or similar instruments as surveillance techniques have been

effective in the detection of triatomine colonisation process that it is difficult to confirm with manual sampling at low densities (2,10,11,12,13). The efficacy of manual sampling when compared with this passive method results unrelavant (10,14, 15). In terms of control of the infestation, the incorporation of the inhabitants in the triatomines capture and subsequent use of plastic bags measured the community participation in this study during the post-intervention period. Undoubtedly, this was the most sensitive follow-up test, especially at the beginning of the surveillance phase.

Although the evaluation period was too short to observe dramatic changes in the serology of the population, a highly significant reduction in positive cases was observed in the sprayed community. A more sensitive serological parameter to detect *T. cruzi* transmission is the serology of the children in the 0-4 year's age group that were born after the interventions. A few positive cases were detected in this stratum, but none could be attributed to vector transmission, supporting the assumption of a successful interruption of the *T. cruzi* transmission by vectorial way in these communities during this period. However, it is important to note that the congenital via in all these cases could be possible due to the confirmed positive serology in all their mothers.

The selection of an appropriate vector control intervention for large-scale application should be based on a cost-effectiveness analysis. Taking into consideration the general financial cost of each intervention of US\$ 700 for housing improvement and US\$ 29 for the spraying process (16), the insecticide spraying was the most cost-effective mean of vector control in a post-intervention period of 21 months. However, the combined intervention of housing improvement and housing improvement alone as a large-scale campaign is economically unfeasible. Besides, longitudinal studies have shown that poor house improvements without community surveillance did not alter the triatomine prevalence in houses (14,17). On the other hand, some studies confirm that making appropriate house improvements after insecticide application could be the best solution to avoid triatomine infestation (15), while others showed that this combination did not avoid triatomine reinfestation (18). Thus, for large-scale campaigns, looks appropriate the application of vector control tools that could guarantee a success in

the vector elimination with a well-planned social approach in the community. In the follow up evaluation between pre and post-intervention periods, a drastic reduction of dwelling infestation was observed in the three localities after the intervention process but seroconversion still occurs. Thus, additional measures as educational programs or permanent community participation in the entomological surveillance phase should be performed. Moreover, a national program for the control of Chagas disease vector should perform control tasks at two different levels. Firstly, a drastic control of the vector density based on the systematic spraying of the communities plus vector surveillance performed by the community itself and secondly, through a long-term control that incorporates housing-improvement. The latter should not be considered only as an alternative for the control of Chagas disease vector but as a choice to improve the quality of life in rural populations located in chagasic endemic areas.

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