Chagas disease prevention through improved housing using an ecosystem approach to health

Prevención de la enfermedad de Chagas vía mejoramiento de la vivienda com un enfoque ecosistémico de la salud

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Abstract *This Chagas disease prevention project via housing improvement aims to determine the efficiencyof different interventions in vector control. The following study describes the target communities, disease magnitude, and housing improvements. Transmission levels are analysed from an ecological and socioeconomic perspective. Special interest was focused on the peridomicile as the origin of domiciliary reinfestation. In the original project, three intervention programs were proposed, one for each of the three communities: (a) an insecticide spraying program; (b) a housing improvement program; and (c) a combined program of spraying and housing improvement. The three communities currently have different risks of exposure to triatominae reinfestation as a consequence of the type of intervention carried out. A new multidisciplinary approach which integrates participatory, community-based research and socioeconomic dimensions will allow to determine the efficiency of models for territorial ordering, community education, and environmental interventions in Chagas disease control.*

Key words *Chagas Disease; Triatominae; Insect Vectors; Ecosystem; Public Health*

Resumen *El proyecto de prevención de la enfermedad de Chagas vía mejoramiento de la vivienda tuvo como objetivo determinar la efectividad de diferentes intervenciones para el control vectorial. El siguiente trabajo describe las comunidades intervenidas, la dimensión de la enfermedad y el mejoramiento de la vivienda en el contexto familiar. Los niveles de transmisión se analizan con una perspectiva ecológica y socioeconómica. Especial interés se ha dado al peridomicilio como lugar de origen de las reinfestaciones domiciliares. Tres programas de intervención fueron propuestos para estas tres comunidades: (a) rociado con insecticidas; (b) mejoramiento de la vivienda; y (c) combinado de rociamiento y mejoramiento de la vivienda. En la actualidad, las tres comunidades tienen riesgos de exposición diferentes al proceso de reinfestación triatomínica como consecuencia del tipo de intervención realizada. Un nuevo abordaje transdisciplinario, que integre la investigación participativa de las comunidades y las dimensiones socio-epidemiológicas, permitirá determinar la efectividad de modelos de ordenamiento territorial, de educación comunitaria y del ambiente sobre el control de la enfermedad de Chagas.*

Palabras clave *Enfermedad de Chagas; Triatominae; Insectos Vectores; Ecosistema; Salud Pública*

Introduction

Chagas disease is a rural disease associated with poor socioeconomic conditions and deficient housing. It was initially an enzootic that circulated exclusively among wild animals, transmitted by wild triatomines (WHO, 1991). When humans entered the natural foci and altered the triatomine ecosystem equilibrium, domiciliary invasion became possible. Domiciliation of some triatomine species infected by *Trypanosoma cruzi*, the causative agent of Chagas disease, has extended the disease to artificial ecotopes where the domiciliary cycle was established with humans and domestic animals. This transportation can be accomplished by several mechanisms, characterizing the endemic's determinants in several geographical environments (Da Silva, 1986).

According to conservative estimates by the World Health Organization (WHO), 90 million individuals are exposed to the risk of acquiring Chagas disease, while 16 to 18 million are already infected (WHO, 1991).

In Latin America, Chagas disease ranges from the southern United States to southern Argentina (WHO, 1991). In Paraguay, studies conducted in 1986 by the National Malaria Eradication Service (SENEPA) reported 14% of triatomine infestation and 20% of human *T. cruzi* infection (Rojas-de-Arias, 1996). In 1986, the Health Sciences Research Institute (IICS) conducted a seroepidemiological survey that found a prevalence of 20% in most endemic areas (Rojas-de-Arias, 1996). A recent serological survey in 56-58 class conscripts from all regions of the country showed a prevalence of 3.9% (Vera-de-Bilbao, personal communication). Estimates of Chagas disease incidence rates point to 14,680 new infected individuals per year and a yearly loss of work due to early deaths from acute and chronic Chagas disease amounting to some 30 million dollars (Schofield & Dias, 1991).

There are two basic acknowledged strategies for the control and prevention of Chagas disease. The first is to destroy intra- and peridomiciliary triatomine foci by chemical control with insecticides, and the second is to prevent the vector from domiciliating by improving housing conditions (Schofield & Dias, 1991). The first strategy is currently led by the Triatomine Elimination Initiative in the Southern Cone and Central American countries (Schofield, 1992). This campaign has been followed by a community surveillance program to avoid reinfestation. This is the longest, most expensive, and most difficult phase to maintain (Paulone et al., 1988). In addition, coverage achieved by insecticide spraying and the lasting effects at different post-spraying times are essential (Diotaiuti & Texeira-Pinto, 1991; Gurtler et al., 1994; Ferro et al., 1995; Rojas-de-Arias, 1995).

Housing improvement is a long-lasting and more expensive strategy with difficulties pertaining to economic factors in the target population and also affected by migration, housing dispersion, and land tenure, among other factors. However, housing improvement goes beyond vector control, since it also ensures better overall living standards (Briceño-León, 1990; Bryan et al., 1994; Rios, 1997; Rojas-de-Arias et al., 1999).

It is difficult to compare the cost of these strategies based on their effectiveness, especially when a simultaneous evaluation within the same methodological process is attempted. That is why there are few studies offering feasible alternatives to government programs to justify operational costs in both cases. The project described below arose out of the concern by a multidisciplinary group that was studying suitable materials for maintaining triatomine colonies and the possibility of transforming structures to attack the microclimate in the insects' ecotopes.

The project

The Chagas disease prevention project via housing improvement in Paraguay was conducted by the Center for Appropriate Technology (CTA), Universidad Católica Nuestra Señora de la Asunción (UCA), and the Institute for Research in Health Sciences (IICS), Universidad Nacional de Asunción (UNA). It was supported by the International Development Research Centre (IDRC) (UCA/UNA, 1994). The aim was community participation and short-term results with the additional possibility of extending the benefits to neighboring countries.

Objective

The project's objective was to determine the effectiveness of different Chagas disease control interventions in rural areas. The main actors in this study were families and small communities from whom we expected continuous use of the project results, especially maintenance of the housing improvements.

Methods

Three intervention programs were proposed in three similar communities, with the following predictive variables: (a) an insecticide spraying program; (b) a housing improvement program and; (c) a combined spraying and housing improvement program (UCA/UNA, 1994).

Family participation in housing improvement was assumed when at least one member of the family participated with the assigned instructor in performing the improvements planned jointly with the family members. Family and project contributions were discussed and agreed upon with individual heads of families.

Target variables

The resultant variables used for the evaluation of the impact produced by the interventions were: adaptation of anti-*T. cruzi* serology at the rural level; triatomine infestation; and natural infection measured before and after the planned interventions (UCA/UNA, 1994).

The study's underlying concept of health and disease

Chagas disease within a social context was approached in terms of its undeniable sociocultural dimension due to the fact that there is an association between forms of social organization and precarious living conditions. The point of departure was the conceptualization of health/disease as a socially adapted relationship. The disease's asymptomatic phase and the late-onset symptoms make it an apparently non-existent disease, hampering a grasp of the risk to individuals and consequently affecting the implementation of preventive measures. The incorporation of populations at risk into a participatory model wherein health and housing conditions are evident can be guaranteed by an educational component that represents the disease in social terms.

Time frame

- **First phase**

October 1988 to May 1989: (a) selection of sites; (b) approaching the communities and presentation of the project to them; (c) baseline diagnosis (serological and entomological surveys in the three communities); (d) participatory diagnosis; and (e) preparation of educational modules.

- **Second phase**

August 1989 to October 1991: (a) demonstrations of intervention activities; (b) operational determination of beneficiaries in housing improvement activities; (c) spraying of households (Cañada); (d) housing improvements (Ñanduá); (e) combined spraying and housing improvements (Ypaú); (f) return to the communities with information obtained in the surveys; and (g) application of health education modules related to Chagas disease.

- **Third phase**

October 1991 to January 1992 (post-intervention): (a) variations in domiciliary infestation; (b) levels of serological infection; (c) attitude towards the vector, desire to maintain housing improvements; and (d) maintenance of epidemiological surveillance.

- **Fourth and final phase**

August 1992: A seminar to discuss and publicize the results was held with the presence of university and government authorities.

Results and discussion

Ecological characteristics of target communities

From an ecological viewpoint, the three communities belong to an export-type artificial ecosystem (Forattini, 1976). That is, they were systems in which energy quotas needed for the population's consumption were generally drawn more for individual or family survival than from a collective perspective. The communities are located in a subtropical zone with only secondary plant cover. Mean yearly temperature is 21ºC with a high of 39ºC in summer and low of 2ºC in winter. Mean annual rainfall is 1,500-1,600 mm per year. The three rural communities belong to the Department of Paraguari, located in the central region of the country, in three different districts located 35, 80, and 130 km, respectively from the national capital, Asuncion.

Ecosystem organization

The ecosystem organization includes a description based on ecological, cultural, and economic dimensions related to the domicile, community, and region *vis-à-vis* Chagas disease.

- **Ecological dimensions in relation to domicile, community, and region**

Characterization of geographic space as related to the Chagas endemic in the target communities is linked to cotton and sugar cane farming, small-scale livestock operations, a subsistence economy, small farms (when owned), low family income, substandard multiple-use housing (rooms for both human use and crop storage), crowding, a disorganized peridomicile, and especially the presence of *Triatoma infestans* at relatively high densities and high *T. cruzi* infection rates. There is thus heavy dependence on the artificial ecosystem, formed by humans surrounded by domesticated animal and plant species, thereby increasing interrelations between these variables in this relatively isolated biocenosis. The types of housing, water supply, and excreta disposal are other individual characteristics serving as the starting point for environmental contamination, accompanied by gastrointestinal diseases and parasitism. Such factors can also cause intense domiciliation of arthropods, with the presence of rodents and marsupials, increasing the possibility of transmission of other infectious diseases besides American trypanosomiasis, like visceral leishmaniasis and viral diseases. The degree of deterioration (or inversely, conservation) of the ecosystem's organization is expressed an impoverishment with consequences for the inhabitants' health. The determinants have been outlined more specifically and in a multivariate context in Tables 1 and 2.

- **Cultural, social, and economic parameters**

Homes or huts with thatched roofs, adobe or unfinished brick walls, and dirt floors prevail

Table 1

Chagas disease ecological dimensions and approach levels.

	Environmental variables	Definition of variables and relationship to the ecosystem	The disease in the ecosystem context	Impact of the interventions in relation to the ecosystem context
Household	Local construction materials: adobe or wattle with cracks, bricks without mortar, straw or palm trunk roof, dirt floor. Poor-quality recycled materials.	Crevices in wall, dark interior, crowding of family belongings, grain storage. Microclimatic conditions suitable to the vector.	Suitable vector conditions, domiciliated species. Family crowding facilitates food for vector. Domestic animals incorporated into the domicile, feeding sources of sinanthropic animals. Characteristics of the peridomicile.	Elimination of vector microhabitat from domicile by eliminating cracks and conducting housing improvements. Elimination of vectors by chemical spraying.
Community	Community's degree of dependency on the ecosystem. Macroeconomic projects. Cash crops like cotton, sugar cane, and tobacco plus subsistence crops and ecological conditions of the community surroundings.	Disorganized peridomicile, grain storage, corrals, chicken coops.	Domiciliary and peridomiciliary vector species, woodpiles, sinanthropic reservoirs. Dispersion of dwellings. Characteristics of peridomicile.	Elimination of vector from the community by massive interventions involving spraying, housing improvements, and domiciliary spraying with greater impact on vector populations. Reinfestation by the same or different species.
Region	Degree of ecosystem conservation. Extensive deforestation, ecological imbalance. Macroeconomic projects.	Transitory harvest, precarious buildings in crop areas, passive vector dispersion. Increase of vector population in hot season. Quality of health system.	Primary farming, low yields, poorly marketed produce. Migration to new settlements, endemic expansion.	National plan for rural housing improvement, national program for Chagas disease control. Development poles at regional level.
Global	Seasonal variations. Predominance of subtropical climate I.	Environmental changes. Rain and drought periods. Economic interests in macro projects.	High temperatures, reproduction of vector in two generations per year. Acute disease cases from September to March.	Environmental management, highway and road improvement. Better quality. Prioritization of electricity, water, and gas programs.

as the ideal niche for triatomine breeding and survival. Most housing materials in the communities are recycled and poorly processed during building (Rios, 1997). Most people (86.8%) in the three communities speak *Guarani* as their daily language, and although they can understand Spanish, they are more fluent in their mother tongue (UCA/UNA, 1994).

Monthly family income for 50% of the interviewees ranged from 200 to 400 thousand *guaranies* (approximately US$100.00) (UCA/UNA, 1994). Chagas disease itself was almost unknown to the inhabitants, and although they were all familiar with the vector (the *vinchuca*, or kissing bug), they did not relate it to any disease. None of the communities has a health post, and access to health services is related to the distance to the urban area or the closest community with a Ministry of Health extension service.

- **Ecological and socioeconomic variables as related to disease transmission**

A close relationship has been observed between vector-related ecological variables and type (or conditions) of house-building materials in different sites, location as related to urban centers, and mean number of household members (Table 3).

When infestation indexes, crowding, and natural infection of the vectors increase, higher positive serology rates are observed in the population. The most substandard housing was in Ypaú. In Cañada, although the house-building materials are the same, the upkeep is better. Thus it is not just the materials themselves but the conditions which facilitate vector domiciliation (Rojas-de-Arias et al., 1999). In Ñanduá, the only community where housing improvements were made, reinfestation was the sole

Table 2

Socioeconomic and cultural dimensions and levels of approach to Chagas disease.

	Cultural	Social	Economic
Individual	Perception of the disease. The disease does not exist. New culture for individuals coming from the countryside to urban areas. Limitations of rural population because of self-esteem attached to Guarani language. Perception of needs.	Women in charge of the family health. Their decision to improve of family housing. Their participation in home improvement work. Level of schooling. Morbidity and deterioration. Social stigma towards people with Chagas disease.	Low productivity. Survival. Social impact of morbidity. Disability-adjusted life years.
Family/ household	Multiple usage of the dwelling, often for temporary purposes. Home ownership.	Jobs for housing improvement. Community spraying. Community surveillance. School participation in surveillance.	Land ownership and family farming, family income. Contributions to home improvement project or spraying. Contribution of local manpower and local materials.
Community organization	There are no community organizations. There is no culture of savings.	Prioritization of municipalities in control and education related to Chagas disease. Formation farming cooperatives.	Marketing of community products. Joint harvests. Road improvements for marketing products. Course on health problem solving.
Municipal government	There is no municipal budget for health. Health system centralized.	Lack of medical care for Chagas patients. Prenatal control of pregnant women with Chagas disease in some areas (including the project).	Municipal contribution to control programs. Designated staff. Mobility. Vehicles.
Region	Different cultural norms in different ethnic groups.	Situation of counties, prevalence of infestation and serology in the population. Heath priorities.	Population expelled from some areas, migration to new settlements, wage earners to urban areas. External contribution to development programs.
Country	Culture of peasant exploitation still exists in large areas of the country.	Control of the disease as a decision by the Ministry of Health and housing improving in the national housing plan.	Low farm prices. Failure of cotton growing plan, alternative products with low yields, large migratory movements to urban areas. National plan of agricultural revitalization.

Table 3

Variables related to housing, triatomine indices, and serology in the population from three target communities.

Communities	Construction materials	Triatomine indices of *Triatoma infestans*					Serological index	Average no. inhabitants/ house
		Domiciliary infestation	Peridomiciliary infestation	Crowding	Colonization	*T. cruzi* infection		
Ñanduá	Wall: brick	32.7%	14.6%	3.5	7.0	11.4%	14%	4.11
Rural: 1	Roof: tile	(20/61)	(9/61)			(9/61)	(37/265)	
Ypaú	Wall: wattle and brick	48.5%	27%	5.4	100	27.1%	19.4%	4.99
Rural: 2	Roof: straw and tiles	(34/70)	(19/70)			(20/92)	(63/325)	
Cañada	Wall: wattle and wood	45%	7.8%	3.6	93.3	4.6%	28.5%	4.10
Rural: 3	Roof: straw	(23/51)	(4/51)			(1/22)	(49/172)	

1: low (close to urban centers)
2: intermediate
3: high
Crowding: nº of captured triatomines/nº of houses with triatomines
Colonization: nº of houses with nymphs/nº of houses with triatomines x 100
Infestation: nº of houses with triatomines/total houses examined x 100
Trypanosoma cruzi infection: nº of positive triatomines/total of triatomines examined x 100
Serological index: nº of T. cruzi positive persons/total population examined x 100
Source: UCA/UNA, 1994

factor behind the infested peridomicile (Rojas-de-Arias, 1995).

- **Ecological and socioeconomic variables as related to the disease transmission route**

In vector transmission, the house is the transmission focus. The vector's domiciliary character makes the house an ideal environment for the highest intensity transmission. Environmental deterioration and poor housing are the determinants acting as a transition between the domestic and wild cycles, which include triatomine species and domestic and synanthropic reservoirs that maintain the dynamics of peri- and intra-domiciliary transmission (Schofield, 1985).

Expansion of the Chagas endemic inside the communities is related to migration. Ñanduá, better located and closest to urban areas, showed the highest migration rate. Note that when permanent migration is established in a given area, deforestation begins, due to the use of local materials accompanied by hunting of wild animals and installation of new triatomine colonies by their reinfestation from recently-built neighboring houses or brought passively in family belongings (Benecia & Mercer, 1993).

Establishment of a new vector focus may start expansion in the community by several mechanisms that depend on the triatomine density in the new dwelling, neighboring contacts, and the degree of community organization (Cécere et al., 1996).

Congenital transmission has scarcely been studied at the regional level, although there has been a more extensive analysis at the national level, and especially in the Department of Paraguari, where the project was conducted. Serology is currently positive in some 13% of pregnant women, and congenital transmission is around 10% (Russomando et al., 1998). Congenital transmission is associated with socioeconomic variables like level of schooling (UCA/UNA, 1994), the mother's perception of the disease (González-Terlaz, 1989), family income, and access to health services in a given population. Even though vector elimination has an important impact on Chagas disease transmission, congenital transmission should be approached in the public health context by the regional health services. This should include monitoring of pregnant women with Chagas disease and follow-up and treatment of their infected children.

- **The project's multivariate ecosystem: Socioeconomic and cultural dimensions**

Tables 1 and 2 show the main determinants at different levels and constitute the multivariate Chagas disease system. Note that poor access to health services relates to low coverage of the risk population by public health programs and limited access to curative and preventive pro-

grams. Low productivity of human resources also involves low salaries and lack of work planning, incentives, and sustainability of services (Flecha, 1996). Most Paraguayan families still work at subsistence farming. Original peasant families may no longer work in agriculture, but remain or migrate to central urban areas (UCA/UNA, 1994).

- **Ecological dimensions and approach levels**

The main focus of this study was the modification of artificial domiciliary and peridomiciliary ecotopes, attacking Chagas disease vectors via housing improvements. The project did not evaluate environmental variables like the degree of community dependence on the ecosystem or the degree of the ecosystem's conservation. These important variables have a major impact on the population's quality of life in a holistic context (Contreras & Cordero, 1982). In this aspect, there are experiences relating to adequate land use and Chagas disease. Conservation and rational exploitation of the forest, elimination of housing dispersion, and concentration of a town with a basic sanitation infrastructure around a rural industry has reversed soil degradation, poverty, illness, and migration (Bucher & Schofield, 1981; Schofield & Bucher, 1986).

We believe that an ecosystem approach would have different characteristics in different parts of the region. For example, Ñanduá, the locality where housing improvement was conducted, is involved in the exploitation of a quarry and four brick factories that occupy a relatively limited amount of local manpower. Ypaú, the community with spraying and housing improvements, depends on cotton and sugar cane farming, which uses limited technology and no environmental conservation patterns. Cañada, the community with spraying, is located in an area with large cattle ranches where most of the inhabitants work as day laborers or at small farming with no conservation pattern and a major dependence on the ecosystems (UCA/UNA, 1994).

- **Triatomine domiciliation and peridomiciliation**

Domiciliation is a primary biological phenomenon because its origin is linked to intrinsic population factors and extrinsic factors responsible for influencing the species' evolutionary process (Gomes, 1986). For some, it is a natural selection process because triatomines are hematophagous insects that require sheltered niches and the presence of vertebrates for food (Forattini et al., 1984). The peridomicile with domestic animals has been proposed as both a source of triatomine domiciliary infestation and a barrier by supplying food to the triatomines, thereby avoiding their entrance into the domicile. However, several authors have mentioned the peridomicile as the origin of domiciliary reinfestation after massive chemical spraying (Cécere et al., 1996, 1997). As there are no wild *T. infestans* foci, reinfestation may occur by residual foci after spraying or by passive transport to other infested communities. Besides, once it has been eliminated from its ecotope, other species may rush to occupy the latter (Forattini, 1976). In addition, destruction of residual vegetation increases the number of places (dry trees) favoring triatomine survival and dispersion. A role has been ascribed to pasture crops as a source of *Triatoma sordida* survival and dispersion (Forattini et al., 1984).

- **Socioeconomic, environmental, and health components versus control measures**

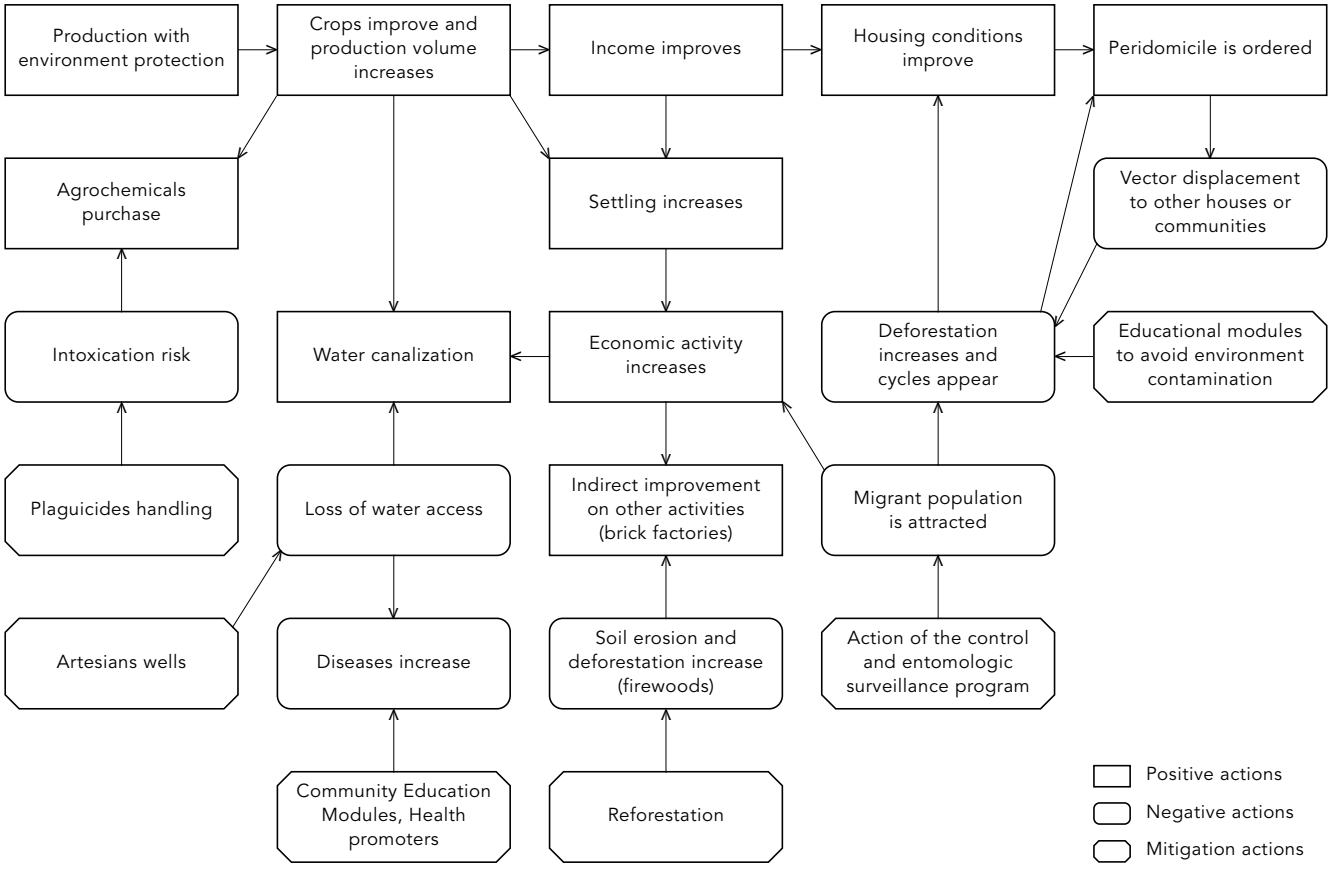
Figure 1 proposes a hypothetical matrix with an ecological approach and broadly covering the main determinants acting in an integrated context. This matrix is established when performing a production and productivity intervention with environmental protection measures in an endemic Chagas disease community as previously described. In this matrix, positive, negative, and mitigating actions interact to maintain the ecosystem's equilibrium. This exercise has allowed us to access the dynamics of the ecological approach in projects aimed at improving the population's living standards. At this point, it is undeniable that the community should take an active part in designing action diagrams as part of local activities.

Overall conclusions

- The Chagas disease control project via improved housing left three communities with different risk degrees of triatomine reinfestation due to the different interventions performed.
- Due to cultural factors and the lack of a surveillance system, passive transport of triatomines in belongings and the migratory process may introduce new foci into the communities and reestablish domiciliary and peridomiciliary transmission cycles.

Figure 1

Interactive diagram of a Chagas disease endemic rural community.



• Integrated and sustainable vector control requires not only spraying, but the incorporation of environmental organization, community mobilization, and participation centered on peridomiciliary entomological surveillance.

• The community should take an active part in designing action plans to be carried out during an intervention project in order to foster community commitment to the complex system.

• It is hard to select variables that only indicate progress in the control of a disease like Chagas in a health context with numerous specific problems, where Chagas disease is not an explicit priority for economically depressed population groups. However, a broad project design to approach these communities again from an ecological and socioeconomic perspective should be addressed.

References

BEBECIA, R. & MERCER, H., 1993. Migraciones y enfermedad de Chagas en la Argentina. *Medicina*, 53 (Sup. 1):38.

BRICEÑO-LEON, R., 1990. *La Casa Enferma. Sociología de la Enfermedad de Chagas*. Caracas: Fondo Editorial Acta Científica Venezolana/Consorcio de Ediciones Capriles.

BUCHER, E. H. & SCHOFIELD, C. J., 1981. Economic assault on Chagas disease. *New Scientific*, 29:321-325.

BRYAN, R. T.; BALDERRAMA, F.; TONN, R. J. & DIAS, J. C. P., 1994. Community participation in vector control lessons from Chagas disease. *American Journal of Tropical Medicine & Hygiene*, 50:61-71.

CECERE, M. E.; GURTLER, R. E.; CANALE, D. & COHEN, J. E., 1996. El papel del peridomicilio en la eliminación del *T. infestans* de las comunidades rurales argentinas. *Boletín de la Oficina Sanitaria Panamericana*, 121:1-10.

CECERE, M. E.; GURTLER, R. E.; CHUIT, R. & COHEN, J. E., 1997. Effects of chickens on the prevalence of infestation and population density of *T. infestans* in rural houses of northwest Argentina. *Medical and Veterinary Entomology*, 11:383-388.

CONTRERAS, H. & CORDERO, L. A. G., 1982. *Ecología. Conservación, Desarrollo. Calidad de Vida*. Caracas: Editorial Génesis.

DA SILVA, L. J., 1986. Desbravamento, agricultura e doença: A doenca de Chagas no Estado de São Paulo. *Cadernos de Saúde Pública*, 2:124-140.

DIAS, J. C. P.; BRICEÑO-LEON, R. & STORINO, R., 1994. Aspectos sociales, económicos, políticos, culturales y psicológicos. In: *Enfermedad de Chagas* (R. Storino & J. Milei, eds.), pp. 527-548, Buenos Aires: Editorial Mosby-Doyma.

DIOTAIUTI, L. & TEXEIRA-PINTO, C., 1991. Susceptibilidade biológica do *Triatoma sordida* e *Triatoma infestans* a deltametrina e lambdacyhalotrina em condições de campo. *Revista da Sociedade Brasileira de Medicina Tropical*, 24:151-155.

FERRO, E. A.; ROJAS-DE-ARIAS, A.; FERREIRA, M. E.; SIMANCAS, L.; RIOS, S. & ROSNER, J. M., 1995. Effect of lambdacyhalothrin on *Triatoma infestans*. *Memórias do Instituto Oswaldo Cruz*, 90:415-419.

FLECHA, O., 1996. *Diagnóstico sobre la Situación del Sector Salud en el Paraguay*. Serie estudios v. 11. Asunción: Centro Paraguayo para la Promoción de la Libertad Económica y de la Justicia Social (CEPPRO).

FORATTINI, O. P., 1976. *Epidemiologia Geral*. São Paulo: Editora Blucher/Edusp.

FORATTINI, O. P.; RABELLO, E. X.; FERREIRA, O. A.; DA ROCHA-E-SILVA, E. & FERREIRA, J. L., 1984. Aspectos ecológicos da tripanossomíase americana XXI. Comportamento de espécies silvestres na re-infestação do intra e peridomicílio. *Revista de Saúde Pública*, 18:195-208.

GOMES-DE-CASTRO, A., 1986. Mecanismos e significado epidemiológico da domiciliação. *Revista de Saúde Pública*, 20:385-390.

GONZALEZ-TERLAZ, S., 1989. Creencias y comportamientos de los campesinos venezolanos frente a la enfermedad de *Chagas*. *Social Sciences and Tropical Disease*, 3:22.

GURTLER, R. E.; PETERSEN, R. M.; CECERE, M. C.; SCHWEIGMANN, N. J.; CHUIT, R.; GUALTIERI, J. M. & WISNIVESKY-COLLI, C., 1994. Chagas disease in Northwest Argentina: Risk of domestic reinfestation by *Triatoma infestans* after a single community-wide application of deltamethrin. *Transactions of the Royal Society of Tropical Medicine and Hygiene*, 88:27-30.

PAULONE, I.; CHUIT, R.; PEREZ, A.; WISNIVESKY-COLLI, C. & SEGURA, E. L., 1988. Field research on an epidemiological surveillance alternative of Chagas disease transmission: The primary health care (PHC) strategy in rural areas. *Revista Argentina de Microbiología*, 20 (Sup.):103-105.

ROJAS-DE-ARIAS, A., 1995. *Evaluation of Chagas Control Techniques in Paraguay*. Ph.D. Thesis, Bangor: School of Biological Sciences, University of Wales.

ROJAS-DE-ARIAS, A., 1996. *Chagas Disease in Paraguay*. PAHO Document No. PAHO/HCP/HCT/72/96. Washington, D.C.: Pan-American Health Organization.

ROJAS-DE-ARIAS, A.; FERRO, E.; FERREIRA, M. E. & SIMANCAS, L., 1999. Chagas disease vector control through different intervention modalities in endemic localities of Paraguay. *Bulletin of the World Health Organization*, 77:331-339.

RIOS, L. S., 1997. La tecnología apropiada para el mejoramiento del hábitat como vía de control de la enfermedad de Chagas. *Revista de la Sociedad Científica del Paraguay*, 1:49-82.

RUSSOMANDO, G.; DE TOMASSONE, M. C.; DE GUILLEN, I.; ACOSTA, N.; VERA, N.; ALMIRON, M.; CANDIA, N.; CALCENA, M. E. & FIGUEREDO, A., 1998. Treatment of congenital Chagas disease diagnosed and followed up by Polymerase Chain Reaction. *American Journal of Tropical Medicine and Hygiene*, 59:487-491.

SCHOFIELD, C. J., 1985. Control of Chagas disease vectors. *British Medical Bulletin*, 41:187-194.

SCHOFIELD, C. J. & BUCHER, E. A., 1986. Industrial contribution to desertification in South America. *Tree*, 1:78-80.

SCHOFIELD, C. J. & DIAS, J. C. P., 1991. A cost-benefit analysis of Chagas' disease control. *Memórias do Instituto Oswaldo Cruz*, 86:285-295.

SCHOFIELD, C. J., 1992. Eradication of *T. infestans*. A new regional Programme for Southern Latina America. *Annales de la Société Belge de Medecine Tropical*, 72 (Sup.):69-70.

UCA/UNA (Universidad Católica Nuestra Señora de la Asunción/Universidad Nacional de Asunción), 1994. *Control de la Enfermedad de Chagas por la Vía del Mejoramiento de la Vivienda*. Asunción: UCA/UNA.

WHO (World Health Organization), 1991. *Report on Chagas' Disease*. WHO Technical Report Series 811. Geneva: WHO.