Chagas' Disease: Control and Surveillance through Use of Insecticides and Community Participation in Mambaí, Goiás, Brazil[1]

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This article describes the nature and effectiveness of methods developed for longitudinal surveillance and control of Chagas' disease vectors in Mambaí, Brazil. The surveillance effort made use of an education program in the schools, community leader and resident participation, specific surveillance equipment (Gómez-Núñez boxes, instructive posters, and instructive calendars with special detection papers), periodic manual collection of triatomines, and a network of collection posts. Spraying of infested houses was accomplished partly by community leaders who received special training for this purpose. The methods used offer an affordable approach to triatomine surveillance and control well-suited to use in large-scale national programs.

In 1974 a project was launched in the municipality[3] of Mambaí, Goiás, Brazil, for the purpose of conducting a longitudinal clinical-epidemiologic study of Chagas' disease. The project was the result of an agreement between the University of Brasília and the municipality. Technical and logistic support were received from the Ministry of Health.

Initially, a series of field studies were performed to acquire knowledge of the population and its relationships with the region's ecology and epidemiology. These studies led to implementation of continuous epidemiologic surveillance methods employing informative posters, simple triatomine detectors (Gómez-Núñez boxes), and paper or cardboard calendars suitable for identifying triatomine feces. These were tested successively in order to develop the surveillance kits for household use that were eventually employed. At the same time, with a view to securing public collaboration, a network of triatomine collection posts was established; this network was supported by an education program in rural schools.

For preliminary assessment purposes, local socioeconomic conditions and the population's perception of Chagas' disease were evaluated (*1, 2*). It was found that, despite their precarious living conditions and lack of knowledge, the people were willing to help control the vector insect, although they did not know how to do so.

Because of this finding, immediately after a large-scale application of insecticides in 1980, the Mambaí population was invited for the first time to participate in epidemiologic surveillance on a trial basis. The ensuing program involved placing instructional posters on house walls or doors. These posters asked people to place any triatomine bugs exterminated by the fumigation in self-sealing plastic bags (distributed ahead of time) and to send them to the local health post (*1, 3*).

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[3]A political subdivision roughly equivalent to a county.

As part of a parallel but separate surveillance activity, an evaluation of household reinfestation was begun. For the purpose of this latter evaluation, triatomines were captured manually (*4*) and were also trapped in Gómez-Núñez boxes (*5*), two of which were hung on the walls of the main bedroom in each home studied. The initial methodology took into account the experience of various researchers (*6–9*).

Distribution of the surveillance kits (*10*) began in 1981. These kits or "units," including an instructional poster and a Gómez-Núñez box with plastic bag attached, provided the means for carrying out the program's first longitudinal (continuous) surveillance work, which in turn established a basis for regular survey activity in Mambaí.

In 1984 five units referred to as "triatomine information and attack posts" were set up in isolated or hard-to-reach areas (*4*). At these posts, community leaders chosen from four localities took on the double role of coordinating the collection post and fumigating infested houses (*11, 12*). Such experience working with inhabitants who sprayed their own houses has previously been reported (*13*).

In 1984, after the school health education program had been launched, eight additional triatomine collection posts were established, half of them at schools. This made it possible to "decentralize" the reporting of triatomine bug captures, enabling people to report such captures at posts relatively near their homes (*11*). Further decentralization was achieved by arranging to have 21 primary health care posts serve as collection points. The overall response to these efforts was so good that in 1985 the program was expanded to cover the entire municipality via a network of collection posts that were located primarily at rural schools.

Meanwhile, a 1984 study of various surveillance techniques indicated that a simple sheet of paper was able to yield evidence of triatomine feces as effectively as the Gómez-Núñez box (*14, 15*). Indeed, subsequent more careful analysis of such sheets showed that they could be used to differentiate the fecal matter of various domestic insects in the region (*16*) as well as to find evidence of triatomine colonization of a specific house (*17*).

Accordingly, after preliminary field testing, beginning in 1988, the aforementioned surveillance kit was replaced with a "minimal surveillance unit" (*18*). This latter unit, which has provided the basis for continuous household epidemiologic surveillance to date, consists of an attractive educational calendar 42 cm × 30.5 cm, a copy of which is shown in Figure 1. The calendar, containing a warning about triatomines and a request for their collection, was hung on the wall of each participant's home above the home's most important blood source (the conjugal bed), so that triatomine bugs could defecate on its front and back surfaces after feeding on the largest available blood mass. Attached to the calendar was a self-sealing plastic bag labeled with the name and address of the head of the household.

Each home's residents were asked to put all the triatomine bugs they captured in the bag and take them to a collection post (one of the triatomine information posts in the more populous areas, or one of the five triatomine information and attack posts in the more remote areas served by the latter facilities) so that workers could respond with appropriate fumigation.

In addition, testing of a cylindrical detection device (50 cm × 10 cm) that could be made by local residents from bamboo cane began in 1988, when the device was placed on the roofs of chicken coops at nine Mambaí locations (see top photo p. 268). This device, designed for continuous detection of residual triatomine bugs in areas around housing units, is cur-

Figure 1. The wall poster in current use. The calendar is used as an instructive poster, reminder, and triatomine fecal detection device in the Mambaí triatomine surveillance and control program (*19*). The "minimal surveillance unit" consists of this calendar and a plastic bag. The calendar says "WANTED; the *barbeiro* [triatomine bug] is bad; it sucks blood, causes choking, can damage your heart; this insect, which people call the *procotó, chupão, percevejo do mato, fincão, borrachudo,* or *barbeiro* causes a sickness known as Chagas' disease; help us fight this; put any *barbeiro* found in the plastic bag and send it to the collection post (TIP, TIAP, TOAC)." TIP = triatomine information post; TIAP = triatomine information and attack post; TOAC = triatomine orientation and attack center.

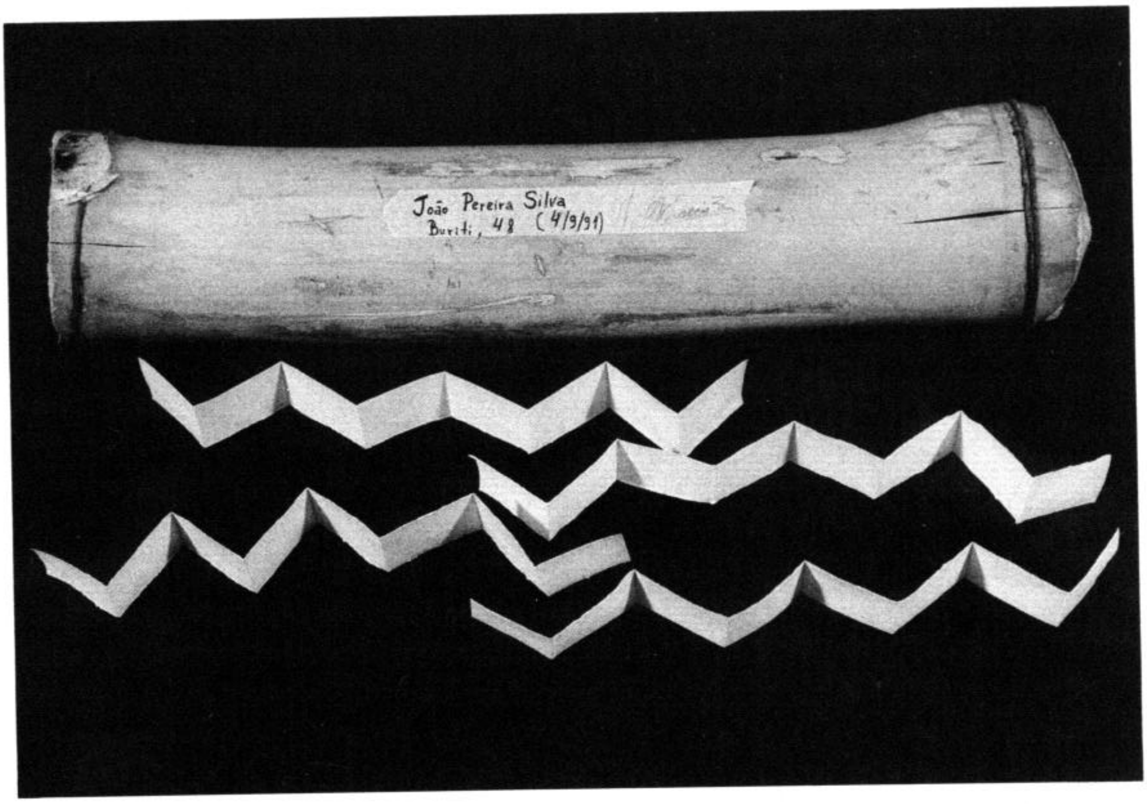
rently being adapted for the community participation program.

One recent article (*19*) and another submitted for publication (*20*) focus on the epidemiologic data obtained to date. The purpose of the present article is to report experience with the triatomine survey methods developed for this project in an area where *Triatoma infestans* was endemic.

METHODOLOGY

The municipality of Mambaí is located 332 km northeast of Brasília in Goiás State, on Brazil's central plateau, and occupies

The peridomiciliary surveillance unit in current use. It is open at one or both ends, contains folded paper inside, and is labeled with the name of the head of the household. (Photo by M.T.A. García-Zapata, 1991.)



View of a Mambaí home improved by plastering, immediately after completion of the work (27).

an area of 1 253 km^2. The project reported here initially included 58 Mambaí localities, mostly to the west (the eastern part of the municipality is uninhabited), with a population of 4 549. At the present time (June 1993) 37 rural localities participating in the triatomine surveillance effort remain under rigorous and continuous observation. (The whole population of the municipality is roughly 10 000 residents.)

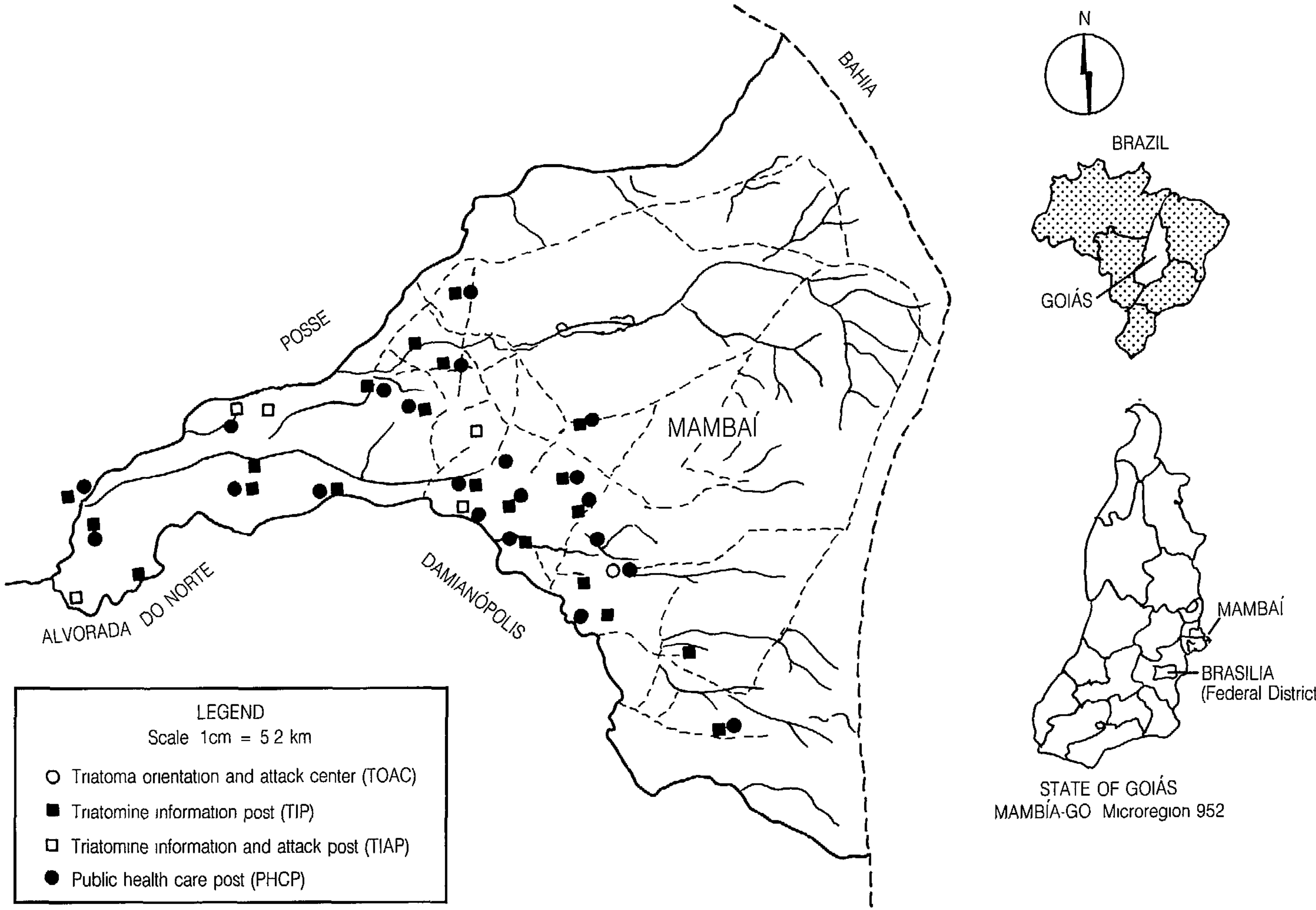
After obtaining the consent of the owners of all the housing units surveyed, the following procedures were performed on an annual basis:

1. Triatomines were captured manually once a year and following a resident's report of their presence. This was done for at least one man-hour using forceps, a flashlight, and an insect irritant spray (pyrethrum) employed to flush out the bugs (*4*).
2. The detection boxes or calendars provided with the triatomine surveillance or minimal surveillance kits were examined (*10, 18*). The interior of each Gómez-Núñez box was carefully checked for live triatomine bugs, exuviae, eggs, and fecal smears. A similarly rigorous examination was made of the outer surfaces of the box and calendar (front and back) for recent triatomine feces, which were distinguishable from those of other common domestic insects such as bedbugs, ticks, and cockroaches (*16, 17*). If the residents' plastic bag for triatomine bug collection had bugs in it, the bag and its contents were taken so that the bugs could later be identified and examined. Finally, a new calendar or boxes were hung on the wall above the double bed at a height of 1.5 meters, out of the reach of children. Where surveillance devices had been placed on chicken coop roofs, these were also examined and changed (*18*).
3. A pyrethroid insecticide (deltamethrin, 0.05 g/m^2) with long residual action and low environmental impact was sprayed in all housing units that showed evidence of triatomine infestation. The findings in the housing unit were discussed with the inhabitants (usually the wife), who were reminded about the importance of the surveillance kit, their continued collaboration, and the continuation of the project. All information obtained was stored in a data base developed for this purpose (DBASE III-PLUS, EPIINFO 5.0).

From 1985 onward, the network of triatomine collection points included a total of 48 facilities (see Figure 2) consisting of one headquarters ("triatomine organization and attack center") in Mambaí's urban center, 21 triatomine information posts, five triatomine information and attack posts, and 21 primary health care posts. Sixteen localities had both a triatomine information post and a primary health care post, because by coincidence the health post had been established at the initiative of the health authorities of the municipality at about the same time as the surveillance program. These health posts collaborated voluntarily with the program, giving each participating locality at least one collection point.

The triatomine "information" and "information and attack" posts were units located near schools that were directed by chosen community leaders. Their functions were to receive triatomine bugs captured by residents in their homes as well as reports of such captures, and also to provide residents with general information about Chagas' disease and its control. The community leaders responsible for running the information and at-

Figure 2. Distribution of triatomine collection posts (PHCP, TIP, TIAP, TOAC)[a] in Mambaí; the area without collection posts is unpopulated (*12*).



[a]PHCP = public health care post; TIP = triatomine information post; TIAP = triatomine

tack posts in remote or hard-to-reach localities also did the key work (after prior training) of fumigating the houses where triatomine infestations were reported. Each of these leaders assumed responsibility for a maximum of 25–30 housing units and donated his services gratis to the community.

The inhabitants of participating localities were advised to report finding any triatomines to the collection post nearest their homes. During this period a "resident field worker"—a well-equipped government health agent provided with a cross-country vehicle—made twice-monthly visits to all of the triatomine collection posts (both information and information and attack posts) in the municipality. Except in the localities with triatomine information and attack posts, the agent evaluated, recorded, and fumigated all the houses where any evidence of infestation had been found.

At the five hard-to-reach localities with information and attack posts, supervisory personnel were responsible for reconfirming evidence of triatomine infestation in the housing units and for checking and perfecting the community leaders' fumigation techniques. Each community leader who applied insecticide was provided with appropriate safety equipment—a helmet, a mask, goggles, gloves, and suitable protective clothing—together with a portable insecticide sprayer (see photo p. 272).

The school health education program was conducted through the municipality's school network and was coordinated by the local education department. Initial orientation and retraining were provided by an education team from the regional office of the Ministry of Health. The resident field worker, in addition to being a triatomine collector and fumigator, also served as an educator. Rural teachers were responsible for disseminating and reinforcing the school health education program within the municipality. Schoolchildren were the program's central agents, acting to further disseminate program information and report when bugs were found.

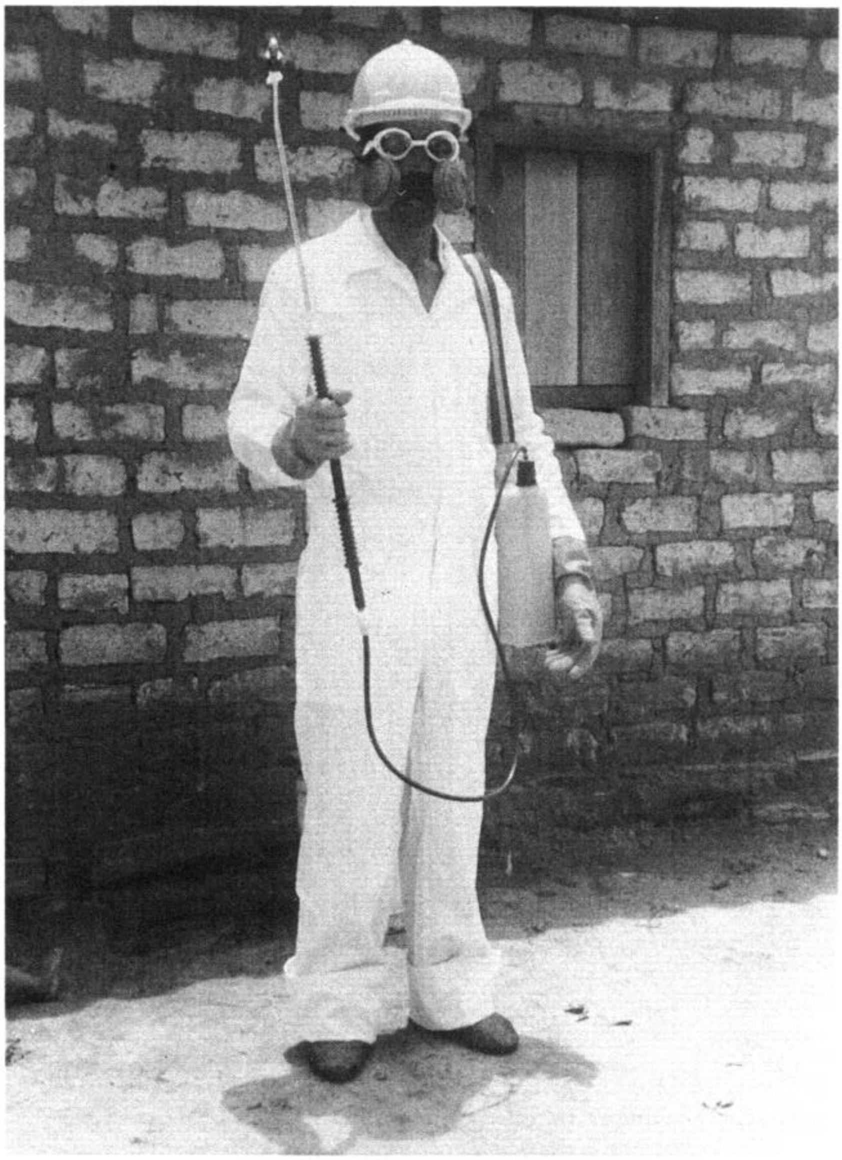
RESULTS

Results obtained from 1980 through 1992 showed that duly confirmed notification (reporting of triatomine bugs by householders) was the surveillance technique that detected the most infested houses (60%). Manual capture using an insect irritant spray to flush out the bugs, the Gómez-Núñez boxes, and deployment of paper or cardboard posters for detecting traces of triatomine feces produced lower detection rates (Figure 3). Overall, the surveillance kits used in homes and the surveillance devices placed on chicken coops detected 65% and 56%, respectively, of the housing units found to be infested (Figure 4).

Not all the originally planned reinforcement and consolidation cycles could be provided in 1986 and again in 1989–1990, because of personnel problems and lack of federal agency (National Health Foundation/Ministry of Health) planning and resources. Even so, at the time of a subsequent 1989 assessment it was found that the health education program conducted in the schools and in the community at large had remained active and dynamic.

Initial evaluation of the triatomine information posts in 1984 revealed that most reports of household triatomine bugs (85.2%) came from posts associated with schools. Data on operation of the network of collection posts is summarized in Table 1. In localities served by triatomine information posts, 60.6% of the infestations in homes found to be infested were reported by the residents, while in those served by information and attack

A community leader responsible for a triatomine information and attack post equipped for applying insecticide—with helmet, goggles, mask, rubber gloves, appropriate clothing, and portable insecticide sprayer.



posts the figure was 70.5%. In general, community leaders responsible for carrying out activities at both types of posts performed their duties diligently. A breakdown of overall program costs is shown in Table 2.

To fumigate each housing unit during the 1984–1992 study period, the community leaders at the information and attack posts used an average of 0.38 liters of insecticide solution (deltamethrin, 0.05 g/m^2), while the field workers used an average of 0.75 liters. Total spray coverage of the triatomine-infested housing units was achieved during this time period. However, spraying was delayed 60 to 90 days at 195 housing units because of the problems mentioned above, which reduced the availability of insecticides and field workers.

During this same period, in the localities served by the five information and attack posts, spraying was delayed approximately 30 days at only four housing units. In two cases the infestation had not been reported to the community leader, and the bugs were detected through the surveillance kit or manual

Figure 3. Percentages of triatomine infestations detected by residents' reports, manual capture of bugs using insect irritant spray, Gómez-Núñez boxes, and detection of triatomine feces on paper or cardboard calendars. Mambaí, 1982–1991.

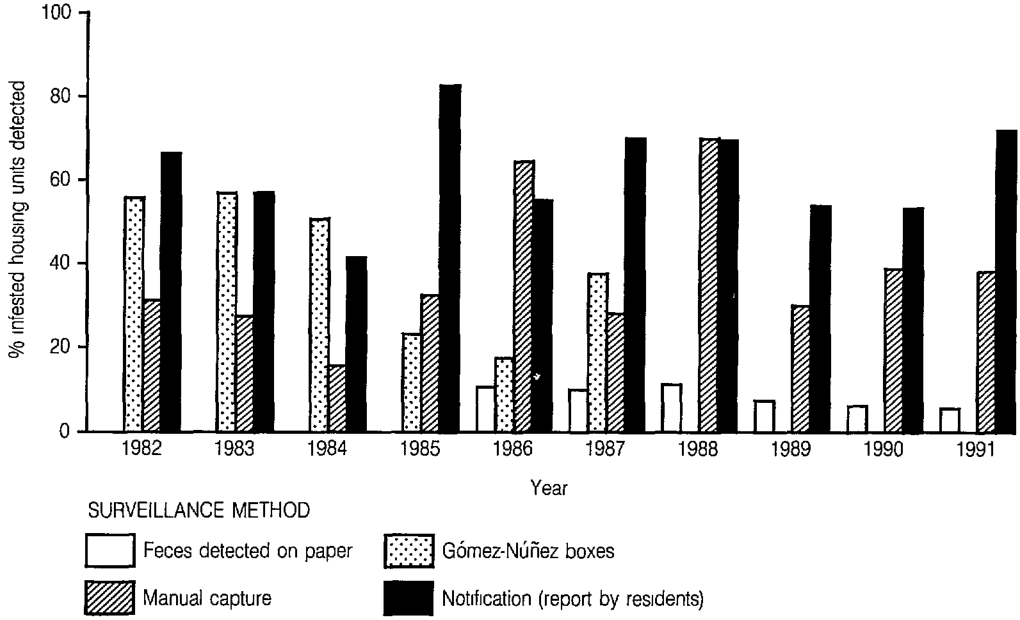


Figure 4. Percentages of triatomine infestations detected by the surveillance devices placed on chicken coops, traditional surveillance units (Gómez-Núñez box, instruction poster, plastic bag), minimal surveillance units (calendar, plastic bag), and manual capture. Mambaí, 1982–1991.

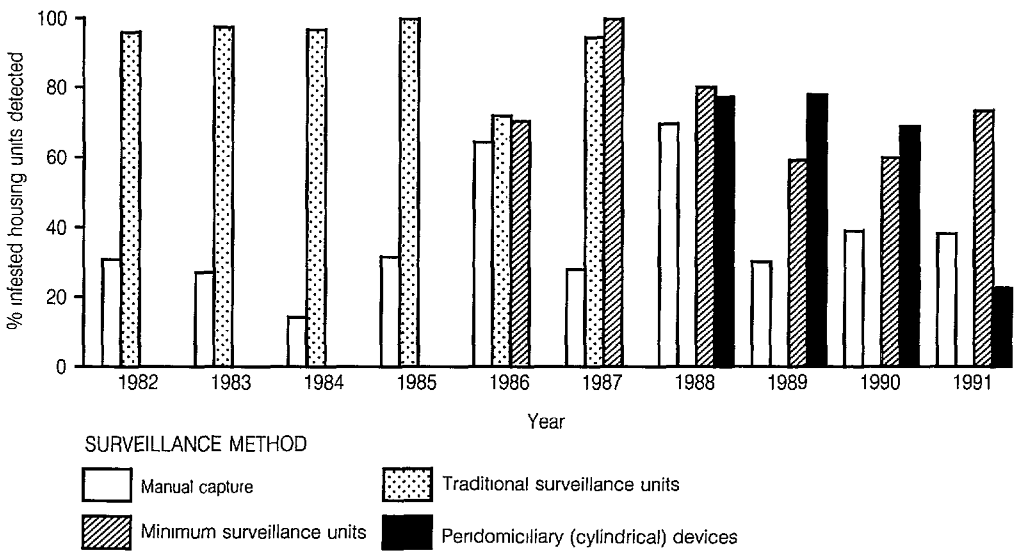


Table 1. Results of the triatomid surveillance program in Mambaí, Goiás, Brazil (1984–1991) in terms of housing unit infestations detected by different methods.

	Study year							
Items	84	85	86	87	88	89	90	91
Triatomine information posts:								
No. of posts	8	21	21	21	21	21	21	21
Housing units surveyed	187	439	445	380	257	214	204	215
Housing units found infested	66	65	104	71	113	80	45	60
Housing units reported infested by residents	50	43	38	46	80	39	20	47
Housing units found infested by positive manual capture	15	19	73	21	29	19	16	21
Housing units found infested by passive detection devices[a]	1	10	14	5	39	30	13	7
Triatomine information and attack posts:								
No. of posts	5	5	5	5	5	5	4	4
Housing units surveyed	82	68	59	56	48	55	33	49
Housing units found infested	18	20	9	19	18	17	19	13
Housing units reported infested by residents	17	16	9	11	5	13	14	7
Housing units found infested by positive manual capture	4	1	3	5	8	10	9	6
Housing units found infested by passive detection devices[a]	5	4	2	6	9	3	0	0
Housing units sprayed	16	18	9	19	18	17	18	13
% coverage by spray program	88.9	90.0	100	100	100	100	94.7	100
Insecticide solution used per housing unit (liters)	0.3	0.4	0.3	0.3	0.3	0.5	0.5	0.4
Rural field workers from the Ministry of Health:								
Housing units sprayed	59	12	93	53	93	44	27	28
% coverage by spray program	89.4	18.4	83.7	74.6	82.3	55.0	60.0	46.7
Insecticide solution used per housing unit (liters)	1.1	0.5	0.3	0.5	0.7	1.0	0.9	1.0

[a]Gómez-Núñez boxes, calendars, cylindrical devices placed on chicken coops.

Table 2. Cost breakdown of the control and surveillance program in Mambaí, Goiás, Brazil (1980–1992).[a]

Item	US $
Price per housing unit:	
Manual capture	*3.70*
Traditional surveillance kit:	*1.01*
1 Gómez-Núñez box	0.95
1 illustrated poster ("Chamex" 100 paper)	0.02
1 self-sealing plastic bag (17 × 15 cm)	0.04
Minimal surveillance kit:[a]	0.18
1 illustrated calendar (240 g poster board)	0.16
1 plain plastic bag (15 × 10 cm)	0.02
Cylindrical surveillance device:	
Plastic cylinder	0.35
Bamboo canes (adaptation)[b]	0.10
Insecticide spraying + surveillance:[b]	
Director, information and attack post	1.92
Resident rural field worker	10.50
Implementation and support activities:	
Education program:	
Initial set-up of the program	150.00
Training for each teacher (initial)	6.81
Support[c]	37.50
1 housing unit monitored per year	0.94
Triatomine information post:[b]	
Implementation	4.82
Annual support[d]	2.29
Triatomine information and attack post:[b]	
Implementation	67.08
Annual support[d]	5.78

[a]Additional annual program costs not included in the main body of the table were as follows: (1) resident technician's salary, US$2 333; (2) maintenance of researcher's house in the field, US$242; (3) field vehicle fuel, US$2 441; (4) field vehicle maintenance, US$1 600.

[b]The community leaders provided their services gratis on a voluntary basis. The resident field worker received a salary from the Ministry of Health. The cost of the bamboo cane adaptation will decline even further with effective community participation.

[c]Visit by the educator in charge for additional training and supervision. The rural teachers received a salary from the Department of Education of the municipality.

[d]Rubber gloves, materials for bug collection, and materials for dissemination of information. The basic spraying, safety, and protection equipment was maintained in good condition; the problems that arose were easily solved. The insecticides used were provided by a federal agency, the National Health Foundation of the Ministry of Health.

capture; while in the other two the delay was due to insecticide delivery problems. At one other housing unit, where a single male *Triatoma sordida* had flown into the dwelling, we instructed the community leader not to fumigate. During the period three community leaders moved to other localities, but replacements for them were found without difficulty. In 1990, as the result of a community decision and reduced triatomine infestation, the number of information and attack posts serving the locality Barreiro dos Porcos was reduced from two to one. None of the community leaders participating in spraying activities exhibited any health problems related to insecticide use.

DISCUSSION AND CONCLUSIONS

In dealing with triatomine infestations, the surveillance phase is typically an expensive and prolonged activity that tends to be discontinued and is often abandoned altogether. This very quickly undoes all the progress made in the earlier phases and gives rise to extremely negative public attitudes that are often impossible to reverse later.

Manual capture, a vertical (as opposed to longitudinal) technique used in most countries with endemic Chagas' disease, is commonly the only method available for evaluating control and surveillance campaigns. However, its effectiveness is limited by various factors, including the following:

1. Human factors; i.e., the catcher's experience, vision, intuition, interest, dedication, level of training, available equipment, etc.
2. Vector biology; for example, the target insect's nocturnal habits.
3. The triatomine load; when it is low, this makes surveillance more difficult.

4. High costs associated with mobilization of field staff in affected areas (*11, 20*).

In addition, because manual capture is a vertical technique, it tends not to reveal the true extent of triatomine infestation (*21*).

Largely because of such problems, the study reported here has been directed at assessing the experience gained in applying alternative triatomine surveillance methods in the Mambaí program over the course of the last decade. These methods are continuous (longitudinal) and appear to provide a model for solution of this problem that is well-suited to application in endemic countries, where both human and monetary resources are almost always in short supply.

It seems clear that the efficient longitudinal techniques used in the earlier pilot project described elsewhere (*11*) could not be fully adopted in a program of national scope because they would not be suitable for large-scale application. However, years of research on alternative techniques that are effective, low-cost, and practical (*14, 15, 18*) have shown that the longitudinal surveillance method using our "minimal surveillance unit" (an illustrated calendar and plastic bag) is appropriate for large-scale applications and is well worth consideration by national Chagas' disease control programs, especially in dealing with remote and impoverished rural areas.

The minimal surveillance unit is practical for rural health agents, being easy to handle and interpret (*15, 16, 18*), and also being capable of revealing probable household triatomine colonization (*17*).

Despite the effectiveness of the triatomine surveillance unit consisting of an informative poster, Gómez-Núñez box, and plastic bag (*10, 14, 21*) in longitudinal detection of infested houses with a low triatomine load, which would not be detected by manual capture (the vertical technique in official use), there were certain factors that motivated a search for new alternatives. These were as follows:

1. Problems with installation, transport, interpretation, and evaluation of the boxes in the field.
2. The costly and complex infrastructure required for establishment and implementation of the techniques employed if they were used as part of a national control program.
3. Observation, once the load of house-dwelling triatomines was reduced, that some Gómez-Núñez boxes were serving as artificial hiding places for certain domestic arthropods such as cockroaches, wasps, spiders, and scorpions, creating a nuisance for the residents while at the same time reducing the household triatomine load in a manner that might temporarily benefit the residents but that could hinder surveillance.

Since prolonged use of these or other similar devices (*14, 21*), such as the María sensor box (22), would run the risk of losing value and community acceptance, such devices are not recommended for programs involving systems of community participation or primary health care (*12, 18, 22*). However, they could prove useful in pilot and experimental studies required during the initial phases of an investigation in a specific endemic area (*3, 9, 11*).

Another consideration that makes the minimal surveillance unit especially desirable is the need to integrate various detection techniques with the same objective, since there is no single technique that would detect 100% of the infestations (*10, 11, 18, 21*). The most accurate technique, owing to its limitations, is not a practical option (23). The method using the minimal surveillance unit, which is a practical option, combines two continuous surveillance techniques: a passive technique based on evidence of feces left by the triatomine bug after a blood meal, and an active technique involving actual capture of the insects by the household residents—who are continually reminded of the need to perform this activity by the presence of the illustrated calendar and plastic bag (*18*).

The surveillance device used in chicken coops proved to be a valuable and effective longitudinal detection tool (*18*) in an area where, until now, only the vertical technique of manual capture has been used. With the consolidation of the community participation program, it is expected that this technique will become more viable and will provide more information about the dynamics of residual triatomine infestations at sites near and around homes.

Networks of triatomine collection and/or attack posts employing insecticide spraying and community participation are genuinely useful and efficient, as well as advantageous from a cost-benefit standpoint, when they are rationally used (*8, 13, 24*). It has also been encouraging to note these rural Brazilian communities' continued willingness to participate for their own benefit, even in the face of labor problems that often affect state institutions and hinder the continuity and efficiency of surveillance programs. At the same time, because poor hygiene (principally under the bed) was found responsible for the persistence of triatomine foci in most homes, it appears essential to have a dynamic, ongoing education program to disseminate information about the disease and its control to the community, one that will make schoolchildren and their teachers key players in the surveillance effort. In this regard, it should be noted that children have proven more effective than adults—who are always busy with work in the fields—because of their ready availability, attentiveness, and ability to quickly disseminate program information (*7, 18, 25*).

Although correct handling of the pyrethroid insecticide sprayers has prevented the occurrence of any insecticide-related health problems among the community leaders of Mambaí (*11, 13, 18*), this is a matter that requires frequent monitoring. In tropical areas the use of insecticide fumigants, proposed as a strategy under primary health care programs (*22*), may not be very effective because of the special characteristics of the dwellings in such regions. An alternative method would be to apply paints containing slow-release insecticides on the walls and frames of dwellings (*26*).

It is important to note that the best solution to a persistent triatomine infestation problem after insecticide application consists of making appropriate home improvements (e.g., plastering) designed to eliminate triatomine refuges—see bottom photo p. 268 (*27*). Indeed, it is generally advisable, even before undertaking a control program, to study the homes involved carefully and, where indicated, to demolish a few houses posing the most difficult problems by hand, as was done in Mambaí. Obviously, different types of houses present different problems; an Andean stone house with a thick straw roof, for example, presents very different control problems than those encountered in this study. Beyond that, however, the solution of making across-the-board physical improvements is outside the reach of most endemic countries. Thus, the situation will remain unchanged until it is possible to improve the basic living conditions of rural residents and organize health education programs that encourage participation by the afflicted communities themselves (*7, 13, 18*).

Finally, it should be noted that the effectiveness of the longitudinal surveillance and community participation techniques described here has been questioned. Specifically, it has been suggested that the activities and continuous presence of investigators in the field were important factors in the success obtained. It should be noted, however, that when this same methodology was tried in another area with no prior experience in Chagas' disease control, the results were equally satisfactory (*28*). It is thus hoped that community participation, coupled with appropriate technology and proper environmental management (*25, 26, 29*), will soon become the surveillance methodology of choice in those Latin American countries where Chagas' disease is endemic (*30*).

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