

Current epidemiological trends for Chagas disease in Latin America and future challenges in epidemiology, surveillance and health policy

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Chagas disease, named after Carlos Chagas, who first described it in 1909, exists only on the American Continent. It is caused by a parasite, Trypanosoma cruzi, which is transmitted to humans by blood-sucking triatomine bugs and via blood transfusion. Chagas disease has two successive phases: acute and chronic. The acute phase lasts six-eight weeks. Several years after entering the chronic phase, 20-35% of infected individuals, depending on the geographical area, will develop irreversible lesions of the autonomous nervous system in the heart, oesophagus and colon, and of the peripheral nervous system. Data on the prevalence and distribution of Chagas disease improved in quality during the 1980s as a result of the demographically representative cross-sectional studies in countries where accurate information was not previously available. A group of experts met in Brasilia in 1979 and devised standard protocols to carry out countrywide prevalence studies on human T. cruzi infection and triatomine house infestation. Thanks to a coordinated multi-country programme in the Southern Cone countries, the transmission of Chagas disease by vectors and via blood transfusion was interrupted in Uruguay in 1997, in Chile in 1999 and in Brazil in 2006; thus, the incidence of new infections by T. cruzi across the South American continent has decreased by 70%. Similar multi-country initiatives have been launched in the Andean countries and in Central America and rapid progress has been reported towards the goal of interrupting the transmission of Chagas disease, as requested by a 1998 Resolution of the World Health Assembly. The cost-benefit analysis of investment in the vector control programme in Brazil indicates that there are savings of US\$17 in medical care and disabilities for each dollar spent on prevention, showing that the programme is a health investment with very high return. Many well-known research institutions in Latin America were key elements of a worldwide network of laboratories that carried out basic and applied research supporting the planning and evaluation of national Chagas disease control programmes. The present article reviews the current epidemiological trends for Chagas disease in Latin America and the future challenges in terms of epidemiology, surveillance and health policy.

Key words: Chagas disease - control - interruption of transmission - *Trypanosoma cruzi*

Chagas disease, named after Carlos Chagas, who first described the disease in 1909, exists only on the American Continent (Chagas 1909). It is caused by a flagellate parasite, *Trypanosoma cruzi*, which is transmitted to humans primarily by blood-sucking triatomine bugs and via blood transfusion.

Chagas disease has two successive phases: acute and chronic. The acute phase lasts six-eight weeks. Once the acute phase subsides, most infected patients recover an apparently healthy state, in which no organ damage can be detected using the current standard methods of clinical diagnosis. The infection can only be verified by serological or parasitological tests. This form of the chronic phase of Chagas disease is called the indeterminate form. Most patients remain in this part of the chronic stage indefinitely.

However, several years after entering the chronic phase, 20-35% of infected individuals, depending on the geographical area, will develop irreversible lesions of the autonomous nervous system in the heart, oesophagus

and colon, and of the peripheral nervous system. The chronic phase lasts for the duration of the infected individual's life.

Chagas disease represents the leading cause of cardiac lesions in young, economically productive adults in the endemic countries in Latin America.

Thanks to a coordinated multi-country programme in the Southern Cone countries, the transmission of Chagas disease by vectors and via blood transfusion was interrupted in Uruguay in 1997, in Chile in 1999 and in Brazil in 2006.

Transmission through vectors

Chagas disease is a zoonosis transmitted in natural foci or ecological units within a well-defined geographical environment. The ecological unit is composed of sylvan or domestic mammals and of sylvan *Triatoma* bugs, both infected with *T. cruzi*. Continuous transmission is assured with or without the involvement of human beings.

These conditions of transmission are present from latitude 42°N to latitude 40°S, meaning *T. cruzi* infection occurs from the Southern United States to Southern Argentina.

There are two stages of the human disease: the acute stage, which appears shortly after infection, and the chronic stage, which may last for many years. After several years of a silent asymptomatic period, 25% of those

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infected develop cardiac symptoms that may lead to chronic heart failure and sudden death, 6% develop digestive damage, mainly mega-colon and mega-oesophagus, and 3% will suffer peripheral nervous involvement (Coura et al. 1983, 1985, Pereira et al. 1985).

Transmission via blood transfusion

The rural-to-urban migration movements that occurred in Latin America in the 1970s and 1980s changed the traditional epidemiological pattern of Chagas disease as a rural condition and transformed it into an urban infection that can be transmitted via blood transfusion.

In most countries in Latin America it is now compulsory to screen for infected blood in blood banks and systems have been established to do so.

Methods for measurement of epidemiological trends on the continent from 1980-2006 and their outcomes - It should be noted that the prevalence and incidence of the disease as well as its mortality are constantly changing as a consequence of the impact of control programmes, human migration and changes in the socioeconomic conditions of the population.

Data on the decreased frequency of new cases of infection by *T.cruzi* in the last decade that has occurred as a result of vector control are presented below in the sections on Sub-regional Initiatives for the Interruption of Transmission of Chagas Disease.

The estimation of the decrease in the rates of incidence of infection by *T. cruzi* in the period under study was made by comparing the age-specific prevalence rates in a given age group in 1980-1985 (at the time when the cross sectional studies were carried out in the different countries) and the age-specific prevalence rates in the same age group in 1997-2006, i.e., 20 years later (Fig. 1, Table I).

Transmission through vectors - Data on the prevalence and distribution of Chagas disease improved in quality during the 1980s as a result of the demographically representative cross-sectional studies carried out in countries where accurate information was not previously available. A group of experts met in Brasilia in 1979 and devised standard protocols to carry out countrywide prevalence studies on human *T. cruzi* infection and triatomine house infestation.

These studies were carried out during the 1980s in collaboration with the Ministries of Health of Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Ecuador, El Salvador, Guatemala, Honduras, Panama, Paraguay, Peru, Uruguay and Venezuela. The accurate information obtained has made it easier for individual countries to plan and to evaluate the effectiveness of national control programmes (PAHO 1974, Cedillos 1975, Marinkelle 1976, Zeledon et al. 1976, Camargo et al. 1984, Ponce 1984, Reyes Lituma 1984, Lopez 1985, Schenone et al. 1985, Sousa 1985, Franca 1986, Salvatella et al. 1989, Valencia 1990) (Table I).

On the basis of these individual countrywide cross sectional surveys, it was estimated that the overall prevalence of human *T. cruzi* infection in the 18 endemic countries is as high as 17 million cases. Some 100 mil-

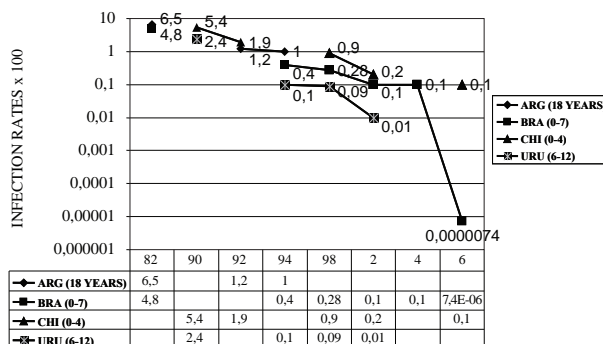


Fig. 1: interruption of transmission of Chagas disease. Southern cone countries, 1982-2006. Infection rates x 100. ARG: Argentina; BRA: Brazil; CHI: Chile; URU: Uruguay. Source: WHO (2002).

TABLE I

Prevalence of human *Trypanosoma cruzi* infection in Latin America, 1975-1985

Country	Population at risk (thousands)	Percentage of total population	Number of infected persons (thousands)
Argentina	6,900	23	2,640
Brazil	41,054	32	6,180
Bolivia	1,800	32	1,300
Chile	11,600	63	1,460
Paraguay	1,475	31	397
Uruguay	975	33	37
Colombia	3,000	11	900
Ecuador	3,822	41	30
Peru	6,766	39	621
Venezuela	12,500	72	1,200
Costa Rica	1,112	45	130
El Salvador	2,146	45	900
Guatemala	4,022	54	1,100
Nicaragua	ND	ND	ND
Honduras	1,824	47	300
Panama	898	47	200
Mexico	ND	ND	ND
TOTAL	99,895	25	17,395

ND: no data.

lion people (25% of all the inhabitants of Latin America) were at risk of contracting *T. cruzi* infection (Table I).

The incidence was estimated to be 700,000-800,000 new cases per year, and the annual number of deaths due to the cardiac form of Chagas disease was estimated to be 45,000 (UNDP/WORLD BANK/WHO 1991).

The original endemic area with vectorial transmission in the human domicile was comprised of 18 countries with higher rates of *T. cruzi* infection in the regions infested by *Triatoma infestans* (Southern Cone

countries) and *Rhodnius prolixus* (Andean countries and Central America), which were the triatomine species best adapted to human domiciles.

The goal of epidemiological quantification was one of the reasons for the prioritisation of disease control but the final political decision came from the demonstration of the high cost-benefit ratio of the control programmes *versus* the costs of medical care and social security for infected patients (Akhavan 1997).

Transmission through blood transfusion - The figures in Table II show the extent of the problem of transmission via blood transfusion in some selected cities of the continent between 1980-1989 (Schmunis 1991). While it varies between 1.3-51.0%, the prevalence of *T. cruzi* infection in blood was much higher than that of hepatitis or HIV.

The transmission of Chagas disease via blood transfusion is a real threat, even for countries where the disease is not transmitted by vectors, such as the USA and Canada, where cases of acute Chagas disease have been documented (Grant et al. 1989, Kichkoff et al. 1987, Nickerson et al. 1989).

The prevalence of infected blood samples in the Southern Cone countries has decreased, as shown by the consistently decreasing trends in all six countries of the sub-region since 1994 (Table III).

Feasibility of interruption of transmission

The tools for interrupting the domestic cycle of *T. cruzi* transmission, such as chemical control, housing improvement and health education, are available. In fact, the prevalence of infection has decreased in countries that have consistently applied control measures. For example, after 20 years of control programmes in Argentina, positive serology in 18-year-old males has been decreasing significantly since 1980, and the number of reported new acute cases has been decreasing since the 1970s (Segura et al. 1985). In Brazil, vector transmission has been interrupted in the whole state of São Paulo since the mid-1970s. Decreasing rates of seropositive school children have paralleled the control efficacy cited above: in 1976, the incidence rate was 60%, whereas in 1983 it dropped to 0% (Souza et al. 1984).

Transmission through transfusion can be prevented if blood is screened serologically and positive units are discarded. In most countries of the region, serology for *T. cruzi* is mandatory for blood donors.

The available information therefore indicates that the most common means of transmission of human *T. cruzi* infection could be interrupted by: (i) implementation of vector control activities in houses in order to first reduce and then eliminate the vector-borne transmission of *T. cruzi* and (ii) strengthening the ability of blood banks to prevent transmission of Chagas disease via blood transfusion through the development and implementation of a policy for screening blood for human use.

Current control programmes

Traditional vertical control programmes in Latin American countries have focused on the spraying of insecticides on houses and household annexes and

buildings. National control programmes aimed at the interruption of the domestic and peridomestic cycles of transmission involving vectors, animal reservoirs and humans are feasible and have proven to be very effective. The goal of eliminating vector-borne transmission is more feasible in areas with domiciliated vectors, like *T. infestans* and *R. prolixus*.

Twelve countries of the Americas have active control programmes that combine insecticide spraying with health education. The common pattern of vertical, centralised control programmes follows several operational steps or phases, namely (i) a preparatory phase for the mapping and general programming of activities and estimation of resources; (ii) an attack phase during which a first massive insecticide spraying of houses takes place and is followed by a second spraying 6-20 months later, with further evaluations for selective re-spraying of re-infested houses and (iii) a surveillance phase for the detection of residual foci of triatomines after the objective of the attack phase has been reached. In this last phase, the involvement of the community and the decentralisation of residual control activities are essential.

A prime example of such programmes is the programme that has been operating in Brazil since 1975, when 711 Brazilian municipalities had dwellings infested with *T. infestans*. This species was the target of the control programme, since it is the most important one from an epidemiological perspective. Ten years later, in 1986, only 186 municipalities remained infested with *T. infestans*. This indicates successful control activities in 74% of the originally infested municipalities as a result of the programmes initiatives. In 1993, there were only 83 infested municipalities, which represent a reduction of 86%.

In 1983, 189,260 *T. infestans* bugs were captured by field workers of the national control programme; however, only 485 insects were found in 1998 and, in 2007, just 205 insects were collected in 21 dwellings in 13 municipalities after a survey of the whole country (MS 2007).

In large parts of the Southern Cone countries, programmes have entered the surveillance phase, which is characterised by monitoring of dwelling infestation and, where necessary, focal spraying.

Economic impact

Programme costs and cost-effectiveness of control interventions - The countries of the Southern Cone Initiative have spent more than US\$ 345 million from their national budgets between 1991-2000 to finance vector control activities in their territories since the launch of the Initiative.

The Ministry of Health of Brazil carried out a study to analyse the cost-effectiveness and cost-benefit ratio of the Chagas Disease Control Programme in Brazil. Due to the chronic nature of the disease and the protracted period of evolution, a period of 21 years was chosen for the analysis. The time interval from 1975-1995 was selected and data from multiple sources were used for analysis (Akhavan 1997).

Effectiveness was defined using various parameters, with the main one being the measurement of the burden of disease prevented, in DALYs (disability-adjusted life-

TABLE II
Prevalence of *Trypanosoma cruzi* infected blood in blood banks of selected countries, 1980-1989^a

Country	Number of samples tested	Percentage positive	Reference
Argentina			
Buenos Aires (1987)	58,284	4.9	Pérez & Segura (1989)
Santiago Estero (1987)	2,003	17.6	Pérez & Segura (1989)
Córdoba (1982)	2,441	8.4	Pérez & Segura (1989)
Bolivia			
Santa Cruz (1990)	205	51.0	Carrasco (1990)
Brazil			
Brasília (1984)	2,413	14.6	Pereira (1984)
Paraná (1987)	3,000	4.8	Marzochi (1981)
São Paulo (1982)	56,902	2.9	Dias & Brener (1984)
Chile			
Santiago (1983)	214	3.7	Liendo (1985)
Vicuña (1983)	62	14.5	Liendo (1985)
Colombia			
Bogotá (1990)	1,128	2.5	Guhl et al. (1987)
Cúcuta (1987)	491	7.5	Guhl et al. (1987)
Costa Rica			
San José (1985)	602	1.6	Urbina (1991)
Ecuador			
Guayaquil (1971)	1,054	3.2	Reports Ministry of Health
Honduras			
Tegucigalpa (1987)	1,225	11.6	Ponce & Ponce (1987)
Mexico			
Puebla (1986)	200	17.5	Velasco Castrejón (1986)
Peru			
Tacna (1972)	329	12.9	Reports Ministry of Health
Paraguay			
Asunción (1972)	562	11.3	Reports Ministry of Health
Uruguay			
Paysandú (1983-1984)	445	4.7	Franca (1986)
Salto (1983-1984)	71	4.2	Franca (1986)
Tacuarembó (1983-1984)	699	7.7	Franca (1986)
Venezuela			
Various cities	195,476	1.3	Schmunis (1991)

^a: data from Schmunis (1991).

years). From 1975-1995, the Programme (excluding blood banks) prevented an estimated 89% of potential disease transmission, avoiding some 2.339,000 new infections and 337,000 deaths. This translated into prevention of the loss of 11.486,000 DALYs: 31% from avoided deaths, and 69% from avoided disability, showing the large role of disability in the overall burden of Chagas disease.

The estimated benefits (expenditures prevented) of the Programme (excluding blood banks) were US\$7,500,000,000, 63% of the savings being from health care expenditures and 37% from social security expenditures (disability insurance and retirement).

The cost-effectiveness analysis demonstrated that for each US\$39 spent on the Programme, one DALY

was gained. This indicates that the Programme and its activities are highly cost-effective. The results of the cost-benefit analysis indicated savings of US\$17 for each dollar spent on prevention, also indicating that the Programme is a health investment with good return. The analysis of other diseases with socio-economic causes demonstrated that the observed decline in Chagas disease infection rates resulted from the preventive activities and was not due to general improvement in life conditions.

The economic impact of the disease during the chronic stage is very high, as shown by data from Brazil. If we consider that about 30% of infected persons will develop severe cardiac and digestive lesions, such

Table III

Estimated number of infections by *Trypanosoma cruzi* and annual incidence in Latin America, 1975-2005^a

Country or region	Total number of infections			New cases		
	1975-1985	1995	2005	1990	1995	2005
Central America and Mexico	1.935,000 ^b	ND	1.906,600	209,187	72,677	16,200
Argentina	2.333,000 ^c	2.100,000	1.600,000	ND	ND	1,300
Brazil	4.500,000	1.900,000	1.900,000	ND	ND	0
Bolivia	1.134,000	ND	620,000	86,676	ND	10,300
Chile	1.239,000	157,000	160,200	ND	ND	0
Colombia	900,000	ND	436,000	39,162	31,330	5,250
Ecuador	300,000	450,000	230,000	7,488	13,365	2,350
Paraguay	397,000	ND	150,000	14,680	ND	900
Peru	643,000	ND	192,000	24,320	19,072	3,100
Uruguay	37,000	ND	21,700	ND	ND	0
Venezuela	1.200,000	ND	310,000	179,703	22,960	1,400

a: data from Schmunis (2007a); b: except Mexico, 1995; c: 1990; ND: no data.

as cardiac arrhythmia (75,000 cases), mega-oesophagus (45,000 cases) and mega-colon (30,000 cases) each year, the estimated costs for pacemaker implants and corrective surgery (average US\$ 5,000) would amount to approximately US\$ 750 million per year, which would be enough for the improvement or construction of more than 700,000 rural dwellings at a minimum estimated cost of US\$1,000 each in Brazil in 2000.

Between 1979-1981, 14,022 deaths in Brazil were due to Chagas disease, representing approximately 259,152 years of potential life lost before the age of retirement. Assuming that all the patients were unqualified rural workers and that the minimum daily wage at the time was US\$ 2.5, the total economic loss due to premature deaths would amount to US\$ 237 million.

Epidemiological impact in the region

The average reduction of incidence in the Southern Cone countries during the period studied is 94%, as shown in Table V. This reduction of transmission of the disease in Southern Cone countries has led to a 70% reduction in the incidence of Chagas disease in the whole of Latin America: the number of incident cases decreased from an estimated 700,000 new cases per year in the whole region in 1983 to fewer than 200,000 new cases per year in 2000, and to 41,200 in 2006. Moreover, the annual number of deaths dropped from more than 45,000-12,500. Furthermore, the number of endemic countries was 18 in 1983, but it decreased to 15 in 2006, as shown in Table V (WHO/TDR 2006).

Intradomiciliary infestation by *T. infestans* was eliminated in Brazil in 2006, in Chile in 1999 and in Uruguay in 1997.

At present, the major challenge is to ensure the sustainability of this programme in an epidemiological context with very low *T. cruzi* infection rates and a political-institutional context of health sector reforms, in which the decentralisation of operations poses the risk that

control activities will lose priority. The new institutional order requires that Chagas disease control be integrated into other services and programmes and become part of a broader scheme for meeting the health needs of the population. In these circumstances, the integrated activities must sustain the significant progress made thus far towards the elimination of Chagas disease.

Initiative of the Southern Cone countries: epidemiological trends

Accepting that the epidemiological and entomological spaces did not overlap with political divisions, the Ministers of Health of Argentina, Brazil, Bolivia, Chile, Paraguay and Uruguay launched the "Initiative for the Elimination of Transmission of Chagas Disease" in Brasilia, in June 1991 (MERCOSUR 1991). Since the vector of *T. cruzi* in these countries, *T. infestans*, is intradomiciliary, sustained implementation of control measures has successfully interrupted transmission of Chagas disease, as indicated below.

At the time, there were 11 million infected persons in these countries and 50 million were at risk. This represented 62% of the prevalence of infected individuals on the whole continent.

Technical representatives of each Ministry were designated to constitute an Intergovernmental Commission in charge of the implementation and evaluation of the control programmes. The Pan-American Health Organisation (PAHO) was appointed as the Secretariat of this Commission and has played a leading role in promotion and coordination.

A programme guide was designed by the Commission; it incorporated revisions submitted by the professional staff of the control programmes and was used to develop the country programmes. The proposed plans for Argentina, Brazil, Bolivia, Chile, Paraguay and Uruguay are approved on a yearly basis by their respective governments.

The objectives of the Southern Cone Initiative were clearly established since its inception and comprised the interruption of vectorial and transfusional transmission. Cooperation among countries was ensured by the formal commitments of the countries that introduced the agreed-upon activities into their national control programmes. Later, other objectives of this Initiative were introduced, such as etiological treatment and medical care of infected patients as an ethical imperative.

Current data (PAHO 2007, WHO 1994, 1995, 1996, 1997, 1998a, 1999a, 2000a, b, WHO/TDR 2006) on deinfestation of houses, blood bank screening and incidence of infection in the under five years age group indicate that the vector-borne and transfusional transmission of Chagas disease was interrupted in Uruguay in 1997, in Chile in 1999 and in Brazil in 2006. Chagas disease was targeted for elimination by the World Health Assembly in Resolution WHA51.14, approved in May 1998 (WHO 1998b), which was recently reviewed by the WHO Executive Board, in January 2009 (WHO 2009).

The model implemented in the Southern Cone was adapted to the Initiatives of the Andean Countries in 1996 and to Central America in 1997 (WHO 2002), and more recently to the Amazon Initiative, in 2004.

The advances in Chagas disease control achieved in the period of 1991-2006 changed the epidemiological model of the disease.

From a general point of view, the most important changes achieved by the Southern Cone Initiative are: (i) interruption of transmission of *T. cruzi* by *T. infestans*, certified in Brazil, Chile, Uruguay, the Eastern Region of Paraguay and five of the endemic provinces of Argentina; (ii) notable reduction of vectorial transmission in Bolivia thanks to house spraying with insecticides in the endemic area and regular vector control activities in Southern Peru, where domiciliar infestation is also caused by *T. infestans*; (iii) reduction of transmission by secondary species in Brazil and (iv) close to 100% blood screening coverage in all the countries, as shown in Table II.

Progress in control in each country is reported as follows:

Argentina - The area of transmission covered 60% of the country north of parallel 44°. The main vector is *T. infestans*. In 1980, the average house infestation rate for the country as a whole was 30%; in 1998, it was 1.2% and, in 2002, it dropped to 1%, which is equivalent to a 98% reduction in house infestation by the main vector.

The seroprevalence rate for the whole country for the 0-4 years age group is 0.9%, which confirms the very low number of acute cases among children in this age group. In the 0-14 years age group, the rate is 1.9%. Among 18-year-old males, the seroprevalence rates dropped from 5.8% in 1981 to 1% in 1993 and 0.5% in 2002. The interruption of vectorial transmission has been achieved in 10 of the 13 endemic provinces of the country (MSA 2002).

Finally, there is 100% screening coverage of blood donations for Chagas disease in the blood banks of the public sector and 80% coverage in the private sector (WHO 1996).

Bolivia - The endemic area covers 80% of the country's territory, which corresponds to seven of the nine Departments. *T. infestans* is the main vector. In 1982, there was an estimated total of 1,300,000 infected persons, with 26% of them showing electrocardiograph alterations. The house infestation rate for the whole country was 41.2% in that year and the infection rate in the vectors was 30%. Infection rates of more than 50% have been reported in blood donors in Santa Cruz (Carrasco 1990).

Data on serological prevalence show a rate of 28.8% in the general population; in the 0-4 years age group, seroprevalence is 22% in Cochabamba, but 0% in Potosí, where there is an active vector control programme. In Tupiza, another department where there is an active control programme, the house infestation rate is 0.8% (PAHO 1998b).

Brazil - The main vector is *T. infestans*. The two other common vector species, *Triatoma brasiliensis* and *Panstrongilus megistus*, are less important in disease transmission.

In 1975, the endemic area comprised 3,600,000 or 36% of the total territory of the country, making it the most extensive endemic area on the continent. This area included 2,493 municipalities in the states of Alagoas, Bahia, Ceará, Espírito Santo, Goiás, Piauí, Mato Grosso, Mato Grosso do Sul, Maranhão, Paraíba, Paraná, Pernambuco, Rio de Janeiro, Rio Grande do Norte, Rio Grande do Sul, Sergipe, Tocantins and the Federal District of Brasília. At present, only the states of Bahia and Rio Grande do Sul are still considered infested by the main vector in residual foci with low density.

House infestation by *T. infestans* has been reduced from 166,000 insects captured in the endemic areas by the control programme in 1975, to 611 insects captured in 1999 in the same areas, which corresponds to a reduction of 99.7% in infestation by this vector. The current infestation rate represents an average of one insect per 10,000 houses surveyed, i.e., an infestation rate far below the minimum required for effective transmission of the parasite to new patients.

The prevalence of human *T. cruzi* infection in the 7-14 years group in 1999 was 0.04%, compared to 18.5% in 1980. This represents a 99.8% reduction in the incidence of infection in this age group.

The results of 94,000 serological tests carried out in a population sample in the 0-5 years group in 2007 indicate that the seroprevalence in this age group is 0%, which can be interpreted as a proof of the interruption of vectorial transmission of Chagas disease in Brazil (A Luquetti, unpublished observations).

The above data confirm the interruption of transmission of Chagas disease by *T. infestans* vectors in Brazil. Based on the above epidemiological and entomological data, an international commission in charge of evaluating the interruption of vectorial transmission in this

country issued a certification to declare the country free of transmission in 2006 (PAHO 1998a, b, 2007, WHO 1997, 2000b).

Chile - The vector responsible for disease transmission is *T. infestans*. It has been eliminated from human dwellings, so transmission is now interrupted.

The overall infestation rate for the country decreased from 3.2% in 1994 to 0.14% in 1999, with a reduction of 99.8% in the last three years. In 1999, there were just 26 *T. infestans* insects captured in the interior of dwellings of the endemic areas in the whole country, which represents 2.5 insects in every 1,000 houses, an infestation rate far below the threshold required for effective transmission of the parasite to new hosts.

The infection rate in the 0-4 years age group in 1999 was 0.016%, which represents a reduction of 98.5% compared to the 1.12% infection rate that was found in the same age group in 1995.

Screening in blood banks in the endemic areas has been mandatory since 1996 and the prevalence of infected samples has been reduced to 0.5%.

An independent commission visited the endemic areas of the country in November 1999 and, based on the above data, certified the interruption of vectorial transmission (WHO 1999a, 2000a).

Paraguay - The main vector is *T. infestans*. Chagas disease is endemic in all rural areas of the country and the house infestation rate in 1982 varied from 10% in the Department of Misiones to 20% in Cordillera.

In a serological survey carried out in 1997 in a representative sample (940 individuals) of children younger than 13 years in marginal areas of the capital city of Asuncion, a significant decrease in prevalence rates was observed in all age groups compared to data from 1972.

Rural/urban migrants to these marginal areas of Asuncion come mainly from Paraguari, Cordillera and Central, which have the highest rates of domiciliary infestation by triatomines. However, the fact that there is 0% prevalence among children younger than four years old indicates the interruption of transmission by triatomines in the urban areas of the capital (PAHO 1998a, b).

Uruguay - *T. infestans* is the only intradomiciliary vector in this country. Since 1997, this species has been eradicated from intradomiciles throughout the country. In 1975, the endemic area comprised the Departments of Artigas, Cerro Largo, Colonia, Durazno, Flores, Florida, Paysandú, Rio Negro, Rivera, Salto, San José, Soriano and Tacuarembó.

The house infestation rate dropped from 5.65% in 1983 to 0.30% in 1997.

The interruption of vectorial and transfusional transmission was certified in 1997 and the whole country is under surveillance. There is 100% coverage of blood screening in blood banks.

The incidence of infection in the 0-12 years age group was 0%, which confirms the interruption of vectorial and transfusional transmission of Chagas disease in Uruguay since 1997 (WHO 1998a).

Initiative of the Andean countries: epidemiological trends

In these countries, there are five million infected individuals, with another 25 million at risk of contracting the infection. This represents 27% of the prevalence of infected individuals for the whole continent.

As the vectors of Chagas disease in these countries are not strictly domiciliated, it is necessary to test and adapt vector control strategies to the local entomological conditions.

In the Andean Countries of Colombia, Ecuador, Peru and Venezuela, the elimination of vectorial transmission was launched at an Intergovernmental meeting held in Bogotá, in February 1997, during which detailed country-by-country plans of action, including annual goals, budgetary needs, evaluation mechanisms and research needs, were prepared (OPS/OMS 1997, Guhl 2007).

The advances made in these countries, both in the development of new methods for evaluation and in control activities, include the following: (i) development of methodologies for risk stratification; (ii) stratification of vectorial transmission risks and limited control programmes in Colombia; (iii) establishment of a national control programme in Ecuador and implementation of activities following risk stratification criteria; (iv) implementation of regular control activities in the MACROSUR region of Peru; (v) re-establishment of vector control activities and entomological surveillance in Venezuela and (vi) close to 100% screening of transfusion blood, as shown in Table I.

Progress in control in each country is reported as follows:

Colombia - The main vector is *R. prolixus*, but *Triatoma dimidiata* has also been described as an effective *T. cruzi* vector.

It has been estimated that a 5% of the population living in the endemic areas is infected, which equates to approximately 700,000 persons. The Departments with the highest infection rates are Arauca (21.1%), Casanare (10%), Santander (6.3%), Norte de Santander (5.2%), Boyacá (3.7%), Cundinamarca (1.9%) and Meta (1.7%).

Screening in blood banks has been mandatory since 1995 and there is 100% coverage throughout the country. In 2001 the prevalence in blood donors was 0.65%, compared to 2.1% in 1998.

The preparatory phase of the national Chagas disease control programme is underway and a map of the country featuring the municipalities at risk has been prepared. Vector control activities with insecticide spraying have been decentralised to the Departments, but there are no data available to monitor the impact of the control programmes.

Ecuador - The main vector is *T. dimidiata*. Transmission occurs in the Provinces of the Pacific Coast, including El Oro, Manabí and Guayas. It is estimated that between 30,000-50,000 persons are infected. However, there are no data on the prevalence of infection by age group, or on house infestation rates by Province.

The preparatory phase of the national Chagas disease control programme is underway. The law reorganising the control programme was enacted in December 1998 and places the programme under the control of the Secretary of Tropical Medicine, with specific functions and budgets. The law on compulsory screening of blood for *T. cruzi* was enacted in August 1998. The seroprevalence of infected blood in blood banks for the whole country is 0.2%.

Peru - The highest prevalence of human infection is found in the Departments of Arequipa, Moquegua, Ica and Tacna, which comprise 8% of the total population of the country. The main vector is *T. infestans* and it is estimated that there are some 394,000 houses infested with the vector and 24,000 persons infected with the parasite. Acute cases are regularly reported from this endemic area, which indicates active transmission. There are no screening programmes in blood banks in spite of a prevalence of infected donations estimated at 2.4%, in 1993.

Venezuela - The main vector is *R. prolixus*. In 1987 the endemic area comprised 591 municipalities in an area of 700,000 Km² and a population of 12 million.

The control programme was officially established in 1966. The objective of the Programme was to interrupt intradomestic transmission through vector control by implementing an insecticide spraying programme. The Programme for the improvement of rural housing, originally initiated in the 1960s, helps rural inhabitants to substitute palm roofs, plaster adobe walls and cement earthen floors. In addition, routine screening for *T. cruzi* in blood banks has been mandatory since 1988.

In children younger than 10 years old, the seroprevalence rates for *T. cruzi* infection have decreased steadily in the last four decades, from 20.5% (1958-1968) to 3.9% (1969-1979) to 1.1% (1980-1989) and finally to 0.8% (1990-1999).

The incidence of infection in the 0-4 year age group has decreased by 90% to less than 1% from 1990-1999. The geographical distribution of *T. cruzi* transmission is restricted to the states of Portuguesa, Barinas and Lara (WHO 1999b).

The prevalence of infected blood in blood banks decreased from 1.16 % in 1993 to 0.78% in 1998 (Aquatella et al. 1987, Aché & Matos 2001).

Initiative of the Central American countries: epidemiological trends

There are two million infected individuals in these countries and 26 million are at risk of contracting the infection. This represents 11% of the prevalence of infected individuals for the whole continent.

As the vectors of Chagas disease in these countries are not strictly domiciliated, it is necessary to test and adapt vector control strategies to the local entomological conditions.

In the Central American countries, Belize, Costa Rica, El Salvador, Guatemala, Honduras, Mexico, Nicaragua and Panama, progress in blood bank control is also proceeding well; all of the countries except one have issued legislation for compulsory screening of blood for *T. cruzi*.

Similarly, the elimination of vectorial transmission was launched at an Intergovernmental meeting held in Tegucigalpa in October 1997, during which detailed country-by-country plans of action, including annual goals, budgetary needs, evaluation mechanisms and research needs, were prepared (OPS/OMS 1997).

The advances made in vector control and in the control of blood transfusions in these countries include: (i) interruption of *T. cruzi* transmission by *R. prolixus* (certified in Guatemala); (ii) interruption of *T. cruzi* transmission by *R. prolixus* in Honduras and Nicaragua (in the process of certification); (iii) reduction of transmission by *T. dimidiata* in several countries; (iv) testing of alternative methodologies for control of *Rhodnius pall-escens* and (v) close to 100% screening of transfusion blood, including in Costa Rica, where it is compulsory, as shown in Table I.

Progress in control in each country is reported as follows:

Belize - The only vector species of epidemiological importance is *T. dimidiata*, but it is restricted to the wild environment. There are sporadic reports of insect adults in the periphery of cities and villages attracted by light. The seroprevalence in the general population is very low, and most seropositive persons found are migrants from neighbouring countries. There is 100% coverage of screening in blood banks, and the prevalence among blood donors in 2000 was 0.5%.

Costa Rica - The main vector is *T. dimidiata*. The vectors are found in the central plain, extending primarily to the Northwest and Southwest Regions of the country. A seroprevalence of 1.94% was found in some of the country's blood banks that participated in a study in 2000. In a recent survey carried out among school children in the Heredia Province in 2001, children 7-12 years old showed an infection rate of 0.2%. Chagas disease is not considered a public health problem here (OPS/OMS 2001).

El Salvador - *T. dimidiata* is the main vector. *R. prolixus* was detected in the country in the 1980s, but this species disappeared from El Salvador in the last decade. *T. dimidiata* is the only vector currently detected in all Departments, with a house infestation rate of 21% in dwellings in rural areas and small or medium townships. In 2000, the prevalence of infection in school children 7-14 years old was 0.3%; it was 2.1% in the population older than 14 years.

Blood screening coverage was 100% in 2000, with a prevalence of infected blood of 2.48%. That year, the vector control programme treated 67.3% of infested dwellings in areas where there was co-infestation by anophelines and triatomines.

Guatemala - *T. dimidiata* is found in 18 of the 22 departments and *R. prolixus* is found in five departments. The infestation rate varies from 12-35%. The infection rate in school children in the five most endemic departments namely, Zacapa, Chiquimula, Jalapa, Jutiapa and Santa Rosa, was 4.9% in a survey carried out in 2000. There is a poor blood bank control system, and the prevalence of seropositive blood donations in 2000 was 0.84%.

Vector control activities are carried out by the control programme of the Ministry of Health in the mentioned Departments with the highest house infestation rates (OPS/OMS 2001). Interruption of transmission of *T. cruzi* by *R. prolixus* was certified in 2005.

Honduras - The main vector, *R. prolixus*, is present in 11 departments of the country and the second vector, *T. dimidiata*, is present in 16 departments. Vectors are present in the departments of Choluteca, Comayagua, Copan, Francisco Morazan, Intibuca, Lempira, Ocotepeque, Olancho, El Paraiso, La Paz, Santa Barbara and Yoro. In 1983, the highest infection rates were found in the Western and Eastern departments and in the Southern Region. About half of the population is estimated to be at risk. Infection rates of 32% or more in the vectors have been reported. The most frequent clinical manifestation is cardiopathy.

Vector control activities are carried out in six of the nine Health Regions of the country.

A recent seroepidemiological survey carried out in areas under chemical control in children aged less than five years was 0.36%; in school children 7-14 years old it was 3.3%. Coverage of transfusional transmission control is 100% and the national seroprevalence in blood donors in 2000 was 1.53%, compared to 11% in 1985 (OPS/OMS 2001). Interruption of transmission of *T. cruzi* by *R. prolixus* is in the process of certification.

Mexico - Vectors and infected mammals are found in the states of Chiapas, Guanajuato, Guerrero, Hidalgo, Jalisco, Mexico, Michoacan, Morelos, Nayarit, Oaxaca, Puebla, Sonora, Yucatan and Zacatecas. The prevalence of the disease is highest in the Pacific Coast states from Chiapas to Nayarit, in the Yucatan Peninsula and in some areas of the central part of the country. Although most of the human infections and clinical forms in Mexico are considered to be mild, there have been recent reports of some cases of mega-viscera. Mexico has not introduced routine screening for *T. cruzi* in blood banks, where 850,000 donations are made every year, and where around 12,760 units of blood could be infected.

There is no vector control programme in place in Mexico, though there is a renewed interest among the health authorities in organising national and state vector control activities.

Nicaragua - *T. dimidiata* is present in 14 of 17 departments of the country and *R. prolixus* is present in five departments. Control of transfusional transmission is practiced in 70% of the blood banks, with a prevalence of infected blood of 0.33%. A seroepidemiological survey carried out in 2000 in school children showed a prevalence rate of 3.3% in this age group (OPS/OMS 2001). Interruption of transmission of *T. cruzi* by *R. prolixus* is the process of certification.

Panama - The main vector is *R. pallescens*, which is found inside the dwellings of the Chorrera district. This vector is also present in palms in the wild environment. *T. dimidiata* is also an important vector. There is no compulsory screening in blood banks or nor is there a vector control programme in place.

Amazon Initiative

The Initiative for Surveillance of Chagas disease in the Amazon Region (AMCHA) was launched in 2004.

This extensive area of a bio-diverse biome rich in tropical humid forests covers 7,275,300 km² with a population density of 1.24 inhabitants/km² (Aguilar et al. 2007).

The epidemiological data needed to assess the magnitude of the problem are scant. In the report of the first meeting held in Bogotá, there is no mention of the burden of disease, except for a mention of the presence of 279 autochthonous cases (252 acute cases and 27 chronic cases) in the whole of the 5,000,000 km² extensive territory of the Brazilian Amazon Region. In addition, it is noted that in the national serological survey (1975-1981), the rate of positivity by state varied between 0% in Amapá and 1.9% in Amazonas. There are no data regarding trends or data regarding annual incidence (Guhl & Schoefield 2004). In the same report, it is only mentioned that in the Colombian Amazon Region, there is positive serology in nine communities of the Department of Guainía, but there are no indications as to the methodology of selection of the population samples (Guhl & Schoefield 2004). On the other hand, for Guyana, Suriname and French Guyana, it is concluded that Chagas disease "is not a public health problem" (Guhl & Schoefield 2004). No information is available on the morbidity caused by Chagas disease in the departments or provinces of the Amazon Regions of Ecuador, Peru and Bolivia.

In the report of the second meeting held in Manaus in September 2004, the risk of the establishment of endemic Chagas disease is discussed and it is mentioned that up to 1998, 17 episodes with 85 cases of possible oral transmission of *T. cruzi* had occurred due to the ingestion of *açai* juice (*Euterpa catinga*) in the states of Pará, Acre, Amapá and Amazonas. Apart from the above information, there are no further epidemiological data on the trends in Brazil or in any of the other countries (<http://cdiaecuniandes.edu.co/AMCHA.htm>).

The advances made in vector control and in control of blood transfusions in this region include: (i) development and standardisation of a surveillance model based on the detection of antibodies against *T. cruzi* through serological analysis of samples collected for the diagnosis of malaria and (ii) this surveillance model has been evaluated in Brazil and partially in Ecuador.

Epidemiological impact - The most significant results in the interruption of transmission have been achieved in the Southern Cone and Central American countries. The national programmes of Argentina, Brazil, Chile and Uruguay had shown important results even before the launching of the Initiative. Fig. 1 shows the current trends of incidence of infections in the Southern Cone countries as a consequence of the elimination of vectorial transmission in Uruguay, Chile and Brazil (Moncayo 1997, 2003).

In Central America, after the creation of the IPCA, the response of the governments was very effective and was complemented by the participation of international cooperation agencies for the financing and execution of control activities. In the Andean countries, the difficulties encountered by the IPA were twofold: on one

hand the variety of epidemiological and entomological situations and on the other hand the different degrees of political commitment of the governments involved. The concept of risk stratification was developed in the context of this Initiative and was an important contribution to the other initiatives (Guhl 2000, OPS/OMS 2004, Silveira 2004). In addition, the need was felt to better define the objectives, such as the elimination of *T. dimidiata* in Ecuador, of *R. ecuadoriensis* in Peru and of *R. prolixus* in Colombia.

With respect to the Amazon Initiative (AMCHA), it is recognised that it is still in an initial phase of generation of knowledge on the magnitude of the problem and development of control methodologies, in particular in Brazil, and to a lesser extent in Ecuador.

The impact of vector control programmes and the possible influence of other variables, such as the general socio-economic development of the populations at risk, can be better evaluated by the trends of the number of cases in different periods. Table I shows these data in three different periods: 1975-1985, 1995 and 2005, to estimate the prevalence, and 1990, 1995 and 2005, to estimate the incidence.

As the information compiled in this Table has different sources (Schmunis 2007a, b, OPS/OMS 2006a, b), the interpretation should be cautious and should be considered as the best estimation of the real epidemiological situation.

The impact on the decrease of the burden of disease measured in DALYS due to Chagas disease was most important in the period of 1990-2001, for both Latin America and the Caribbean. The number of DALYS lost to Chagas disease dropped from 2.8 million in 1990 to 0.8 million in 2001, a reduction of 78%, the greatest reduction observed among the top eight communicable diseases in the region (Schmunis 2007a, b).

The impact of the programmes on mortality due to Chagas disease is evidenced by the reduction in mortality from 45,000 annual deaths in 1980 (Moncayo 1993) to 14,000 in 2001 (WHO/TDR 2006), a net decrease of 70%. Table III summarises the reduction in incidence, prevalence, mortality and distribution of Chagas disease on the continent (WHO/TDR 2006).

In Table IV, the data on coverage of blood bank screening and the percentage of positive samples for 2005 are shown. The sources of this information are the official reports of the governments to the meetings of the Intergovernmental Commissions of the sub-regional Initiatives. These data show the high coverage and low percentage of sero-reactivity in the different countries.

Future challenges

In spite of the progress achieved, there are a number of challenges that lie ahead. They can be divided in three categories: epidemiological, technical and political.

Oral transmission

This route of transmission is well established and documented (Shikanai-Yasuda et al. 1991, Valente et al. 1999, Camandaroba et al. 2002, MS 2005, Rodríguez-Morales 2007). The most salient characteristic of oral

transmission is the fact that several persons are affected simultaneously, pointing to the occurrence of a common source of outbreak through contaminated food. The challenge here is the prevention of oral transmission via the ingestion of beverages such as *açaí* juice (*Euterpe oleracea*, *E. catinga*) in the Brazilian Amazon Region.

In other documented cases of outbreaks by oral transmission, the contaminated food was served at family celebrations and in circumstances that were unpredictable. This was the case in the outbreaks of Teotonia, Catolé do Rocha and Santa Catarina, in Brazil (Shikanai-Yasuda et al. 1991, MS 2007), and in Caracas, Venezuela (Rodríguez-Morales 2008).

The approach for the prevention of these outbreaks is based on surveillance, prevention and management, similar to the control of diseases transmitted by food, as recommended by a group of experts convened by the PAHO in Brasilia, in 2006 (OPS/OMS 2006b).

Transmission in the Amazon Region

The patterns of vectorial transmission in this region are unusual and different from those that were recognised as necessary to maintain endemic levels, such as the presence and colonisation of the household by vectors.

TABLE IV

Coverage of screening of blood for transfusion for *Trypanosoma cruzi* (%) and proportion of positive samples in endemic countries, 2005^a

Country	Coverage of screening for <i>T. cruzi</i> (%)	Positive samples (%)
Southern Cone		
Argentina	100	2,47
Bolivia	80	8,0
Brazil	100	0,21
Chile	87	0,6
Paraguay	99	3,2
Uruguay	100	0,47
Andean countries		
Colombia	100	0,44
Ecuador	100	0,15
Peru	99	0,57
Venezuela	100	0,6
Central America and Mexico		
Belize	ND	0,4
Costa Rica	100	0,09
El Salvador	100	2,4
Guatemala	100	0,79
Honduras	100	1,4
Nicaragua	100	0,9
Panama	97,6	1,4
Mexico	100	0,51

^a: data from OPS/OMS (2006); ND: no data.

Thus, the few known cases of infection by *T. cruzi* are being transmitted (i) via the oral route, (ii) by vectors that enter the dwelling but do not develop intra-domiciliar colonies and (iii) via infection of persons who enter the jungle and make contact with sylvan triatomines, such as *Rhodnius brethesi* during the extraction of *piacaba* (*Leopoldinia piassaba*), a vegetal fibre. (Silveira & Passos 1986, Coura et al. 1994).

Most of the documented cases are due to the ingestion of *açaí* juice and are concentrated in the states of Pará and Amapá, where the production of this fruit is intensive.

Fig. 2 depicts the number of cases by year since the first ones were reported in 1969 (Shaw et al. 1969). These cases were the result of outbreaks and hence triggered by oral transmission.

The special characteristics of the transmission of the disease in this region required a new model of epidemiological surveillance adapted from the traditional one used in the endemic areas, which is based on the detection of intra-domiciliar vectors, the screening of blood for transfusion and the identification and treatment of the congenital form of the disease. In addition, it was necessary to take into account the enormous surface of the territory of this region, which implied very serious operational difficulties.

However, there were other factors to be considered, such as the financial resources allocated by the Brazilian government for malaria surveillance and the feasibility of parasitological diagnosis of *T. cruzi* to be carried out simultaneously in the same slide as for *P. falciparum*. However, it is recognised that the sensitivity of this examination for the detection of *T. cruzi* is low.

The following surveillance activities were proposed at the meeting held in Cayenne in 2005 and were accepted by the PAHO (OPS/OMS 2005): (i) detection of cases using the infrastructure of malaria surveillance; (ii) identification and mapping of environmental markers for the identification of current or potential vector species; (iii) research and monitoring of entomological situations when vector colonisation by some species such as *Triatoma maculata*, *Panstrongylus geniculatus*, *Panstrongylus herreri*, *Rhodnius neglectus* and *Rhodnius stali* is suspected.

The increase in the number of cases in the Amazon states in recent years can be observed in Fig. 3. This increase coincides with the fact that the surveillance programme has been fully operational in the same period.

Globalisation of transmission

The increasing mobility of populations and migration towards non-endemic countries have spread the infection to these countries through blood transfusion, organ transplantation and the congenital form of the disease among migrants. The risk is related to the country of origin of the migrants and the rate of prevalence in that given country.

However, the advances observed in control of transmission indicate that this potential spread to Europe, the United States and Canada might be transitory or decreasing.

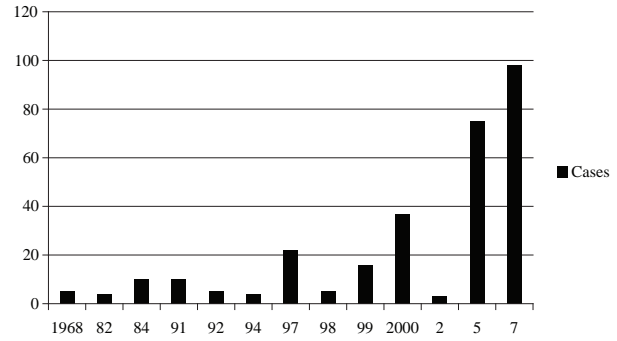


Fig. 2: cases of acute Chagas disease reported from the Brazilian Amazon region, 1968/2007 (source: Gerencia Técnica de Doença de Chagas/ SVS, Brazilian Ministry of Health).

TABLE V

Changes in epidemiological parameters due to interruption of transmission and decrease of incidence, 1990- 2006

Epidemiological parameters	1990	2000	2006
Annual deaths	> 45,000	21,000	12,500
Annual new cases	700,000	200,000	41,200
Prevalence (million)	30	18	15
Population at risk (million)	100	40	28
Distribution (countries)	18	16	15 ^a

a: transmission interrupted in Uruguay in 1997, Chile in 1999 and in Brazil in 2006 (source: WHO/TDR 2006).

The World Health Organisation recently launched the Global Network for Chagas Disease Elimination (WHO Global Network for Chagas Elimination - GNChE) to face this problem.

Local epidemiological situations

There are a number of situations that depend on local circumstances and have implications for vector control operations in the following areas:

1. The Chaco Region

In spite of sustained regular vector control activities in this territory that is shared by Argentina, Bolivia and Paraguay, the rates of infestation by *T. infestans* remain high. The reasons for this are associated with the complex peri-domiciles of the rural houses, the emergence of resistance of the vector to pyrethroid insecticides in the provinces of La Rioja and Salta, in Argentina, and the departments of Tarija and Cochabamba, in Bolivia, and the presence of sylvan foci of *T. infestans*, in Bolivia.

An integrated approach is being proposed that includes the improvement of peri-domiciles and the use of higher doses of insecticide in the peri-domiciles (Gurtler et al. 2007).

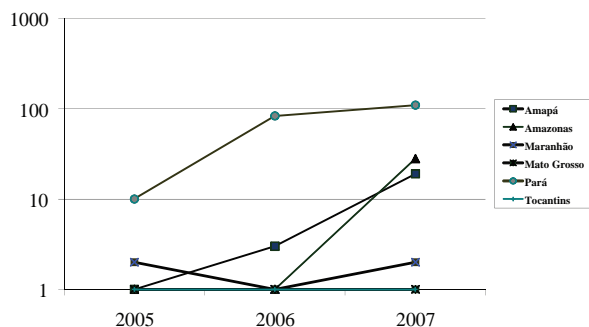


Fig. 3: cases of acute Chagas disease reported from the Brazilian Amazon region, 2005-2007 (source: Gerencia Técnica de Doença de Chagas/ SVS, Brazilian Ministry of Health).

2. Areas with vectorial transmission without intra-domiciliar colonisation

In these areas, transmission occurs because of the “visit” of the vector from its natural ecotopes to houses to feed on the inhabitants, after which the insect leaves. This form of transmission has been documented for *R. pallescens*, in Panama and Colombia, where the natural ecotopes of this species are several types of palm trees that are planted around rural dwellings. The *T. cruzi* infection rates in this insect are very high.

Surveillance and control in these particular situations are based on the analysis of variables that influence transmission, such as the ratio of houses to ecotopes, the rates of insect infection by *T. cruzi*, the vulnerability of the dwellings to insect “visits” and the frequency of these “visits” (Zeledón 2003).

Several alternatives for control have been proposed, including physical or chemical barriers and the use of light sources that are not attractive to the insects.

Vector control

Chemical vector control in the peri-domicile - The peri-domicile comprises the annexes, fences, corrals and poultry yards that are built around rural dwellings. The efficacy of the insecticides sprayed in this part of the home is low due to the degradation of the active principle by rain and the continued exposure to sunlight. Other reasons for the low efficacy of insecticides include the operational difficulties of spraying and the lack of order and cleanliness in these spaces. Thus, residual infestations are invariably located in the peri-domicile.

It seems that the only alternative is the physical management of these spaces, including the rearrangement of the structures and the objects found there.

Resistance of vector populations to insecticides - “Control failures” attributed to the cross-resistance of vectors to pyrethroids have been documented in areas of Tarija and Cochabamba, in Bolivia, and in Salta and La Rioja, in Argentina. Some field tests have been carried out with other insecticides such as carbamates and phosphorates, with poor results. It is necessary to develop and test new molecules to overcome this emerging resistance.

Low sensitivity of entomological methods - The methods available for the direct detection of domiciled triatomines have low sensitivity, especially in circumstances where the insect densities are low, as is the case in advanced control phases. Direct reporting by inhabitants of the presence of domiciliated vectors is more effective and there are studies to evaluate the efficacy of traps with and without attractants such as pheromones.

Political and structural factors

These factors refer to the ranking of disease control priorities within national health policies.

Low political priority in some countries - In some endemic countries, in spite of the evidence of vectorial transmission of Chagas disease, there are no formal national control programmes. A notable case in point is that of Mexico, the only country that has not adhered to any sub-regional initiative nor established its own programme. In view of the variety of epidemiological and entomological situations of this country, it probably requires a new, different approach.

Maintaining political priority - At present, the major challenge is to ensure the sustainability of the national control programmes in an epidemiological context with very low *T. cruzi* infection rates in the younger age groups of the populations of several countries and negligible house infestation rates.

The national programmes should be adapted to the new epidemiological circumstances but should be maintained with an emphasis on entomological surveillance to avoid that the government efforts, financial and otherwise, to attain the interruption of transmission be in vain. The successes accomplished in this respect should not be “punished,” but rather maintained.

It is proposed that the stratification of risk be the central criterion in shaping the required surveillance and control activities (OPS/OMS 2004, Silveira 2004).

Decentralisation of control programmes - As of the 1980s, the traditional vertical programmes for disease prevention and control are being dismantled in accordance with the current political and institutional context of health sector reforms; consequently, the decentralisation of operations may result in a risk of *T. cruzi* control activities losing priority.

The vertical programmes were characterised by a high specificity of activities, strict planning, clear definition of measurable goals and investment of important financial resources.

The decentralisation of programmes has resulted in the lack of recognition by local authorities of the priority given to Chagas disease control, in view of more pressing needs for immediate attention.

The new institutional order requires that Chagas disease control be integrated into other services and programmes and become part of a broader scheme to meet the health needs of the population. In these circumstances, the integrated activities must sustain and expand the significant progress that has been achieved so far in the interruption of transmission of Chagas disease in several countries of Latin America.

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