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IAMAT

When Hiking Through Latin America, Be Alert to Chagas' Disease

Geographical distribution of main vectors, including risk areas in the southern United States of America

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COURTESY ENDS IN DEATH

Valle de los Naranjos, Venezuela. It is late afternoon, the sun is sinking behind the mountains, bringing the first shadows of evening. Down in the valley a *campesino* is still tilling the soil, and the stillness of the approaching night is broken only by a light plane, a crop duster, which periodically flies overhead and disappears further down the valley.

Bertoldo, the pilot, is on his final dusting run of the day when suddenly the engine dies. The world flashes before his eyes as he fights to clear the last row of palms. The old duster rears up, just clipping the last trees as it sommersaults into the forest. Although death does not claim the pilot at this moment, his fate is sealed when the *campesino* drags him, stunned but unhurt, from the plane. He gratefully accepts the farmer's offer to spend the night in his home, a poorly constructed dwelling commonly found in rural areas of South America and known as *el rancho* (the hut), with walls of adobe, a dirt floor and a roof of palm fronds.

On his ride back to Valencia the next day, Bertoldo reflects on his good fortune. Only three months earlier he had come from Italy and he was now employed in his new country in a job he liked. In the accident he had not even been scratched and other than the wrecked plane, he had nothing but insect bites to show for his adventure.

Bertoldo's luck was short-lived. Two weeks after he spent the night in the *campesino*'s hut, he came down with a fever and the right side of his face became red and puffy. He grew progressively weaker, and a few weeks later he experienced heart failure. As a result of the bite of an insect known as the *vinchuca*, Bertoldo had become infected by a parasite, *Trypanosoma cruzi*, the cause of Chagas' disease. Three months later Bertoldo was dead.

THE VINCHUCA

The carrier of the parasite that causes Chagas' disease is a smooth, oval-shaped insect, brownish in color, and belongs to the subfamily of Triatominae in the *Reduviidae* family (order *Hemiptera*). The insect (see illustration below '**a**' – *Rhodnius prolixus*) is two centimeters in length, has a long, narrow, cone-shaped head with two antennae and a proboscis (elongated appendage) that curves under the head and ends in a groove in the upper part of the thorax. On the lateral aspects of the abdomen are narrow stripes of light yellow or red alternating with dark brown. The insect has a limited flight range; although it has two pairs of wings, these are used mainly as a parachute. One of the insect's aliases is 'vinchuca' deriving from the Quechua word *huinchucum*, meaning "one who lets himself fall down".

Both female and male depend on the blood of vertebrates for survival. The vinchuca is nocturnal, hiding during the day in wall crevices and in palm frond roofs, coming out at night to feed. It is attracted to exposed parts of the body and has a preference for the face – it is called *barbeiro* (barber) in Brazil. In Europe and North America it is called the kissing bug, conenose bug, or more appropriately, assassin bug.

When the vinchuca finds the exposed face of a human victim, it places itself in the feeding position, lifts the proboscis and flexes the distal segment upwards, releases a stylet with fine teeth from the proboscis and perforates the skin. A second stylet, smooth and hollow, taps a blood vessel. This feeding process lasts at least twenty minutes during which the vinchuca ingests many times its own weight in blood.

During the feeding, defecation occurs contaminating the bite wound with feces which contain parasites that the vinchuca ingested during a previous bite on an infected human or animal. The irritation of the bite causes the sleeping victim to rub the site with his or her fingers, thus facilitating the introduction of the organisms into the bloodstream. The parasites are also capable of penetrating the intact thin layer of cells covering the mucous membrane of the mouth, nostrils, and eyes (conjunctiva).

FROM FOREST TO VILLAGE

Forest-dwelling animals, which naturally harbor the parasite *Trypanosoma cruzi*, used to be the only source of blood for the vinchuca. The possum, armadillo, and various rodents are natural carriers of the parasite thus Chagas' disease is primarily a parasitic disease of the forest. When humans intruded into the forest ecosystem they unwittingly transported the insects (that naturally live and breed in forests, particularly palm trees) and with them the parasites, into the heart of rural communities. An additional link is provided by the naturally infected possum (*Didelphis marsupialis*) and rats (*Rattus norvegicus*, *Rattus rattus*) which live both in the jungle and in domestic settings.

Of the more than 100 species of Triatominae insects in the Americas, only a few have adapted from the sylvatic or forest ecosystems to the domestic environment. Some have been very successful, like the *Rhodnius prolixus* which transmits the parasite causing Chagas' disease in Colombia and Venezuela, or *Panstrongylus megistus* in Brazil, or the most widespread vinchuca in South America, *Triatoma infestans*. In Central America, the *Triatoma dimidiata* is the main carrier of the parasite. Triatominae species are also present in the Caribbean and in the southern United States, particularly in South Texas where local transmission is widespread in wildlife and domestic dogs.

Adaptability to the domestic environment assures the vinchuca with an immense source of blood from humans and domestic animals such as dogs, cats, and guinea pigs. (Cattle, goats, and pigs play a lesser role in the transmission of the disease. Chickens and pigeons are immune to the infection because their high blood temperature kills the parasites.) A plentiful supply of food spurs the vinchuca into vigorous activity; the insects feed more frequently resulting in profuse procreation causing heavy infestation in dwellings.

THE PARASITE

When the vinchuca feeds on infected humans or animals it ingests the *Trypanosomes* (Gr.: *trypanon=borer*; *sōma=body*) – see illustration below '**1**'. These protozoa (Gr.: *proto=primitive*; *zoon=animal*) belong to the family of *Trypanosomatidae*, which also includes among its members the *African Trypanosomes* causing the disease known as African sleeping sickness.

Seen under the microscope the *Trypanosoma cruzi* has an elongated body with a whip-like flagellum on the anterior part which arises behind the nucleus and is attached to an undulating membrane running along the body.

The parasite evolves through a cycle of four phases, two phases in the vertebrate host and two in the gut of the insect. As soon as the *Trypanosomes* [at this stage called *Trypomastigotes* (Gr.: trypanon=borer; mastix=whip) – see **'1'**] reach the gut of the vinchuca, they undergo a physical transformation into *Promastigotes* [(Gr.: *prós=in front*; *mastix=whip* – the flagellum arises in front of the nucleus) – see **'2'**], a phase during which they reproduce to form new parasites called *Epimastigotes* (Gr.: epí=near; mastix=whip – the flagellum arises near the nucleus) – see **'3'**. These move to the rectum of the insect, resuming their former shape, and are expelled with the feces infecting the new victim.

Having perforated the skin, the *Tryposmastigotes* invade the cells of the adjacent fat tissue, where they transform themselves into *Amastigotes* (Gr.: a=without; mastix=whip) – see **'4'**. These round-shaped parasites reproduce in large numbers forming a pseudo-cyst which distends the membrane of the fat cell until it bursts. Before the pseudo-cyst bursts, the *Amastigotes* will again assume the shape of *Trypomastigotes*, and when released into the bloodstream will rapidly invade the cells of various organs of the body, most frequently the heart. There they will again multiply and grow into pseudo-cysts, which will burst and release the parasites to invade more healthy organ cells. The cycle repeats continually.

THE DISEASE

At the site of introduction of the parasite, usually the face, a hard violet-hued swelling appears after one week. This lesion is called "chagoma de inoculación," after Dr. Carlos Chagas who first described it. In the majority of newly infected persons the *chagoma* affects the skin of the eyelid or the conjunctiva called 'Romaña's sign'. This signals the localized reaction to the presence of parasites as the white blood cells and other elements of the body's defense system surround the clusters of parasites in the fat cells, destroying both fat cells and parasites.

Inevitably however, some parasites escape and reach the bloodstream invading the heart, brain, liver, and spleen, producing a generalized acute form of the disease in about two percent of patients, mostly small children. Fever, rashes, loss of appetite, diarrhea and vomiting, swollen lymph nodes and an enlarged liver are symptoms in this acute phase. In severe cases, meningoencephalitis or inflammation of the brain occurs, mostly in children, and may lead to death.

In adults, the acute infection of the heart is the main manifestation, causing the heart muscle to become enlarged in direct proportion to the intensity of the infection. As soon as the parasites enter the cells of the heart, the defense mechanisms begin to act. The tiny blood vessels dilate and plasma fluid escapes through the walls, inundating the spaces between the fibers of the heart muscle.

At the same time, white cells and other elements of the body's defense system will surround the infected fibers initiating the process of phagocytosis (Gr.: phagein=to eat; kútos=cell) crushing the parasites and the infected fibers to bits and swallowing them up with enzymes. The lesions thus produced, decrease the contractility of the heart reducing its output which leads to heart failure. Approximately 10 percent of patients die during this acute stage of infection. Bertoldo, the person in our story, died of this acute form of the disease. However, his death left a legacy to medical research. The strain or subspecies of the parasite that killed him (named 'Bertoldo strain' after him) is still being cultured in laboratories and used by scientists to study the impacts of the parasite on the heart.

In most cases, however, patients who experience an acute heart infection will see their symptoms subside within four to eight weeks and the victim continues to live an apparently healthy life, joining the large population of infected persons without any history of illness. This condition represents the majority of victims with Chagas disease: Displaying no visible manifestation of the disease, it may go unrecognized for years until a routine blood test discloses it. By then, they have unknowingly become a human reservoir for the infection and contributed to the propagation of the lifecycle of the parasite.

Although latent in its manifestations, the infection gradually progresses, surfacing after 10 or 20 years in the form of chronic heart disease. During this time, the infected heart muscle fibers are slowly replaced by scar tissue, thinning the walls of the heart, sometimes so severely that, at the apex, it bulges out like a balloon (aneurysm). The scar tissue and the thinning of the walls affect the dynamics of the heart so severely that irreversible heart failure results with death occurring within a year. In some cases, the parasites infect the fibers along the impulse-conducting system of the heart, causing disorders of the rhythm which may lead to sudden death unless a pacemaker is implanted.

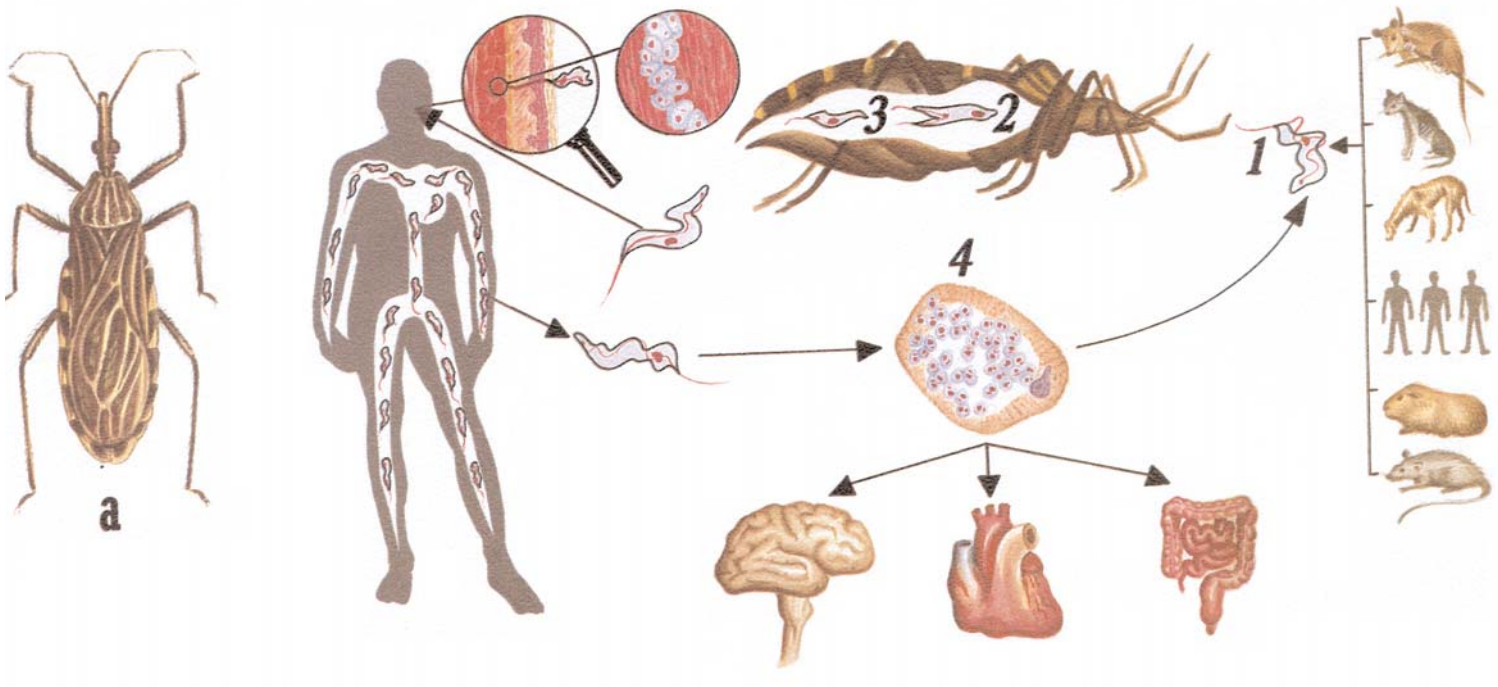
Studies of chronic Chagas' disease patients indicate that not only the central nervous system but also the peripheral nervous system are irreversibly damaged by the parasites, causing partial paralysis, convulsions, psychiatric abnormalities due to lesions in the brain tissue, loss of motor sensitivity due to damage done to the spinal chord, and changes in bodily functions due to the damage caused to the autonomous nervous system.

In some areas, chronic Chagas' disease often manifests itself in the digestive tract, called *megaviscera*, most commonly affecting the esophagus and the colon. Difficulty in swallowing and severe constipation are signs of parasitic infection in these organs.

SOCIAL IMPLICATIONS

Chagas' disease is a serious health problem in rural Latin America. Between 16 and 18 million persons are infected and an estimated 100 million are exposed to this affliction which impairs the physical activity of persons during their most productive years. The disease mostly affects people living in poor socio-economic conditions and drastically reduces their life expectancy.

Internal migration of rural populations has brought the infection to the periphery of cities like São Paulo, and in some countries the disease has reached the interior of urban areas like Cochabamba in Bolivia and Guayaquil in Ecuador.



Besides spreading the infection to towns, the migration of infected persons poses an additional risk through blood transfusions and organ transplants. Congenital transmission from infected mother to child occurs not only in rural areas but has become a problem in many urban areas. Some people are eager to sell their blood and infected blood donors sometimes slip through the screening procedures set up by health authorities. Surveys of blood bank donors indicate a 60% infection rate in the Santa Cruz, Bolivia area. Another source of Chagas' disease transmission can occur by ingesting foods and fruit juice contaminated with the feces of infected Triatominae insects.

To assess the extent of Chagas' disease, routine surveys are conducted throughout Latin America. In Buenos Aires, the National Health Department conducts daily screening programs, and for every 100 people examined finds one unsuspecting person with the infection.

The drugs benznidazole and nifurtimox are effective in killing the parasites in the acute phase of the disease, but not all strains of the parasite are susceptible to the drugs.

Drug treatment in the chronic phase of the disease may clear the patient of parasites. However, in cases where lesions to the heart, brain and other organs have already occurred, treatment will not reverse the damage but may arrest further deterioration.

PREVENTION

Improved housing, which requires extensive changes in existing economic and social conditions, is fundamental to any plan to control and prevent Chagas' disease. Some countries, such as Argentina, Brazil, and Venezuela, the most active in control efforts, have national policies, but these are still far from being fully implemented.

The elimination of the parasite-carrying insects is another major step in the prevention of Chagas' disease. Trials with DDT have not been successful. The chemical gammexane (benzene hexachloride) has proven highly effective, but it must be applied at least three times a year since the eggs of the vinchuca are not affected by the chemical. Dieldrin, of the same chemical family, has also been used with good results.

Fumigant canisters and insecticidal paints have been successfully used in pilot studies in Argentina and Brazil. They have proven to be cost effective and efficient in reducing the vector infestation rates in rural dwellings.

IMPACT OF CHAGAS' DISEASE ON THE INTERNATIONAL TRAVELLER

Because of the nature of travel and accommodation, hikers and campers are particularly vulnerable to Chagas' disease. It is essential that travellers have some knowledge of the disease and how to avoid it. The same applies to people working in the interior of the country such as aid personnel, missionaries, archeologists, anthropologists, geologists, and birdwatchers.

Business travellers spending the night in the periphery or suburbs of cities ought at a minimum to check for insects in their bedrooms.

Chagas' disease is insidious – an international traveller passing through endemic regions of Central and South America may become infected, but may remain apparently healthy until the first signs of chronic heart disease appear years later. Chagas' disease is rarely diagnosed outside Central and South America since the symptoms of this chronic form mimic those of coronary heart disease.

At present, no drugs or vaccines are available to prevent the establishment of the infection in the body.

See IAMAT's Chagas' Disease Risk Chart below showing infected regions. The principal vectors are also mentioned, including the altitude at which the risk may occur, as some insects, like *Triatoma infestans*, still thrive at 3500m / 11,483ft.

RULES FOR PREVENTING CHAGAS' DISEASE

- When travelling in endemic areas, do not sleep in huts since the infection-carrying insects shelter in the palm frond roofs and in the wall cracks.
- When choosing a campsite, stay away from palm trees; do not set your tent close to stone or wood piles where the insects may be hiding.
- When checking into modest or older hotels (alojamientos), search for hidden insects under the mattress, behind picture frames, in drawers, or dark corners of the room. Carry repellents and insecticides with you.
- Before sleeping, apply insect repellent to exposed parts of your body (available in sprays, lotions, and towelettes), which may help to keep the insects away. Any commercially available preparation containing DEET (N, N-diethyl-meta-toluamide) is suitable.
- Use bed nets to prevent contact with insects. Put a cloth over the bed net to prevent the feces of infected insect from falling on you.
- Protect your hands with a cloth, paper, plastic, or gloves if it is necessary to handle the insects.
- If you require medical or surgical treatment involving blood transfusions, avoid private hospitals (clinicas) where blood donors may not have been adequately screened. There is no risk of becoming infected this way at a university or civic hospital in a major city. In Argentina, Brazil, Chile, Honduras, Uruguay, and Venezuela blood bank screening is compulsory by law.
- Avoid ingesting foods and fruit drinks from unknown sources such as street vendors or outdoor markets.

HISTORICAL OUTLINE

1907, State of Minas Gerais, Brazil: Carlos Chagas, while investigating malaria in Brazil, observed the presence of a protozoan (which he later named *Trypanosoma cruzi* in honor of Dr. Oswaldo Cruz) in the intestine of the Triatominae insect *Panstongylus megistus*.

Two years later, he described the same parasite in the blood of a child with fever and enlarged lymph nodes of the neck. He proved the *Trypanosoma cruzi* to be the cause of a disease common in some areas of Brazil.

Dr. Chagas' discoveries made him the first person in the history of medicine to describe all the different aspects of a disease. He discovered the parasite and its developmental phases, described the vector and the cycle of infection both in the sylvatic and rural environment, and clarified the signs and symptoms present in each phase of the disease. However, Dr. Chagas believed that the parasites were introduced into the victim through the saliva of the infected vectors.

1912: E. Brumpt challenged Dr. Chagas' interpretation and was able to prove that the parasites were transmitted through the feces eliminated by the insect during feeding.

1939, Tucumán Province, Argentina: The findings of Dr. Chagas did not attract the interest of the Brazilian medical profession until the Argentinian Dr. Salvador Mazza, conscious of the social impact of the disease, invited physicians from Argentina to collaborate with him on a systematic investigation to study the extent of the disease.

1960: Experimental campaigns against the disease carried out in the 1950s in South America were replaced by systematic national programs with Argentina, Brazil and Venezuela in the vanguard.

Late 1990s: Uruguay and Chile declared their countries free of *T. infestans* transmission.

2006: Brazil declared itself free of *T. infestans* transmission in urban and suburban areas. However, the infection continues to be present in rural areas.

2009: More work lies ahead and only the elimination of poverty and improvement of living conditions for all will bring Chagas' disease under control.

CHAGAS' DISEASE RISK CHART

ARGENTINA

Chagas' disease is endemic in rural areas below 3600m in the following northern provinces: Catamarca, Chaco, Córdoba, Entre Ríos, Formosa, La Rioja, Mendoza, Salta, San Juán, Santiago del Estero.

Intensive public education and eradication programs are ongoing and have dramatically reduced the house infestation rates of the vector T. infestans. All blood donations in the public health sector are screened for Chagas' disease.

Main vector: *Triatoma infestans*.

BELIZE

Risk is present in forest (sylvatic) ecosystems. Sporadic cases of human infections are reported. Blood supply screening is mandatory.

Main vector: *Triatoma dimidiata*.

BOLIVIA

Chagas' disease is endemic throughout rural and suburban areas below 3600m, with very high human infection rates reported from the departments of Cochabamba (including the city of Cochabamba), Sucre, Tarija, and Santa Cruz.

Main vectors: *Triatoma infestans*, *Triatoma sordida*. The insect is locally known as 'vinchuca'.

BRAZIL

In 2006, urban and suburban areas were declared free of transmission by *T. infestans* (the most domesticated vector) due to extensive public education and eradication programs. However, the extent of human infection in remote rural areas, especially in the Amazon region, is unknown and might be aggravated by increased settlement, deforestation and destruction of forest (sylvatic) habitats. Vectors and wild animal reservoirs are present throughout Brazil.

Main vectors: *Triatoma infestans*, *Panstrongylus megistus*, *Triatoma brasiliensis*, *Triatoma sordida*. The insects are locally known as 'barbeiros'.

CHILE

The entire country has been declared free of Chagas' disease transmission since 1999. Blood supply screening is mandatory.

COLOMBIA
Risk is present in rural areas below 2500m with the highest incidence rates reported from the following departments: Arauca, Casanare, Cundinamarca, Meta, Norte de Santander, and Santander. Since 1995, blood supply screening is mandatory. Public health education and eradication programs are ongoing.
Main vectors: *Rhodnius prolixus*, *Triatoma dimidiata*.

COSTA RICA
Risk is present in rural areas below 1300m along the Pacific coast and the central plain. Guanacaste province reports the highest incidence rate.
Main vector: *Triatoma dimidiata*.

ECUADOR
High risk is present in the following coastal provinces, including urban areas: Guayas, El Oro, Los Ríos, and Manabi. Risk also exists in rural areas of the provinces of Loja, Azuay, Bolivar, and Cotopaxi. Blood supply screening is mandatory since 1998. Public health education and eradication programs have started.
Main vector: *Triatoma dimidiata*.

EL SALVADOR
Chagas' disease is endemic throughout El Salvador. Risk is present in rural areas, small and medium-size towns, and suburbs. Blood supply screening is mandatory.
Main vectors: *Triatoma dimidiata*, *Rhodnius prolixus*.

FRENCH GUIANA
Risk is present in all rural areas.
Main vector: *Rhodnius prolixus*.

GUYANA
The vector *Rhodnius prolixus* is present in rural areas, but due to the lack of investigations on Chagas' disease, the extent of human infection is unknown.

GUATEMALA
Risk is present in rural areas below 1500m with the highest incidence rates reported from the departments of Chiquimula, Jalapa, Jutiapa, Santa Rosa, and Zacapa. The blood supply is not screened appropriately.
Main vectors: *Triatoma dimidiata*, *Rhodnius prolixus*.

HONDURAS
Risk is present in rural areas below 1500m with the highest incidence rates reported from the departments of Choletuca, Comayagau, Cortés, Francisco Morazán, Intibucá, La Paz, Santa Barbara, and Yoro. Blood supply screening is mandatory.
Main vectors: *Triatoma dimidiata*, *Rhodnius prolixus*.

MEXICO
Risk is present in all rural areas. The highest incidence rates are reported from the states of Chiapas, Distrito Federal, Hidalgo, Guerrero, Jalisco, Morelos, Nayarit, Oaxaca, Puebla, Querétaro, Veracruz, Yucatán, and Zacatecas. Only sporadic cases are reported from the two northern states of Chihuahua and Coahuila. The blood supply is not screened appropriately.
Main vectors: *Triatoma dimidiata* is present in all infected areas; *Rhodnius prolixus* is also present in Oaxaca and Chiapas.

NICARAGUA
Risk is present in rural areas below 1500m. Public health education and eradication programs are ongoing.
Main vectors: *Triatoma dimidiata*, *Rhodnius prolixus*.

PANAMA
Risk is present in the rural areas of the provinces of Chiriqui, Bocas del Toro, Coclé, Colón, Darién, and Panamá. The highest incidence rates have been reported from Chiriqui, the valley of Río Chagres, and the areas of the Canal Zone adjacent to Río Chagres.
Main vectors: *Triatoma dimidiata*, *Rhodnius pallescens*.

PARAGUAY
Chagas' disease is highly endemic in all rural areas, with particularly high human incidence rates in the Chaco and eastern regions.
Main vectors: *Triatoma infestans*, *Triatoma sordida*. The insects are locally known as 'chinche timbuku' or 'chinche guasu'.

PERU
Risk is present in two separate geographical areas:
1) Rural and suburban areas of departments in the northern part of the country bordering Ecuador: Tumbes, Piura, Cajamarca, Amazona, and Loreto (foci in eastern Loreto in the areas of Javary and Amazon rivers bordering Brazil).
Main vector: *Triatoma dimidiata*.
2) In the southern half of Peru in areas below 3500m, particularly in the rural and suburban areas of the follwoing coastal departments: Arequipa, Ica, Moquegua, Tacna.
Main vector: *Triatoma infestans*. The insect is locally known as 'vinchuca' or 'chirimacha'.

SURINAME
The vector *Rhodnius prolixus* is present in rural areas, but due to the lack of investigations on Chagas' disease the extent of the infection is undetermined. Recent studies did not find positive cases in blood donors.

UNITED STATES OF AMERICA
Local transmission to humans has been reported from the southern United States (Texas, Louisiana, Tennessee and California). Although the infection is present in wildlife and dogs, transmission to humans is rare, possibly due to the type of housing which is not suitable habitat for Triatominae bugs. It is estimated that about 300,000 persons, mostly immigrants, are infected with Chagas' Disease, and congenital transmission has been reported. Mandatory screening of the blood supply for Chagas' Disease has not yet been implemented in all States.

URUGUAY
The entire country was declared free of Chagas' disease transmission in 1997. Blood supply screening is mandatory.

VENEZUELA
Risk is present in rural areas of the following states: Barinas, Lara, and Portuguesa. Extensive public health education and eradication programs are ongoing and have greatly reduced infection rates. Blood supply screening is mandatory since 1988.
Main vectors: *Rhodnius prolixus*, *Triatoma maculata*. The insect is locally known as 'vinchuca'.

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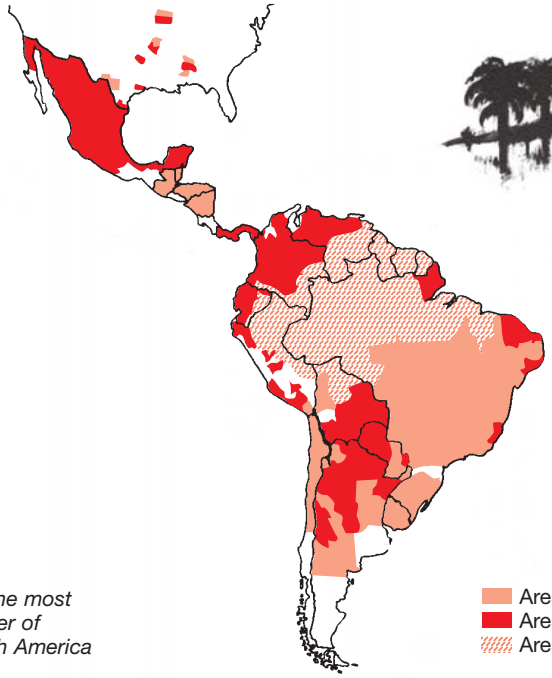
Map source:
Pan American Health Organization, www.paho.org.

***Triatoma infestans**, the most widely spread carrier of Chagas' disease in South America*



Areas with educational and eradication programs in place
Areas with risk of Chagas' disease
Areas with limited data on Chagas' disease and no eradication programs