HARVARD MEDICAL SCHOOL

BRIGHAM AND WOMEN'S HOSPITAL

CASES IN GLOBAL HEALTH DELIVERY

GHD-037
JULY 2017

Chagas Disease Vector Control in Honduras

On the day, in 2012, when Dr. Concepción Zúniga, the chief of Honduras's National Chagas Program, was informed that he was being transferred to another position within the Ministry of Health, he became concerned about the future of the program that he had led and built over the last decade.

In the early days, the National Chagas Program had few data, strategies, or resources, despite Honduras's high burden of Chagas disease. To fight this neglected tropical disease, which mainly affected impoverished rural populations, the Honduran Ministry of Health began a project in conjunction with the Japan International Cooperation Agency (JICA) in 2003. The alliance imported a successful disease control model from neighboring Guatemala, the first country to be certified for interruption of Chagas disease transmission in Central America, and tailored the model to Honduras before scaling it up.

By 2010, Chagas disease prevalence had declined 75% and incidence had declined 92%. In 2011, Honduras was certified for the interruption of disease transmission by the principal insect vector. However, Dr. Zúniga knew that maintaining this success and interrupting the other potential, non-eliminable vector required ongoing effort and funding. How could he ensure that progress would be sustained in his absence?

Honduras

Honduras, with an area of over 112 square kilometers and a population of almost 8.1 million people, lay in the Central American isthmus and was divided into 18 departments (see **Exhibit 1** for a map of Honduras). In 2012, the population, whose principal language was Spanish, was made up of 90% mestizo or ladino, 7% indigenous, 2% black, and 1% white[1,2] (see **Exhibit 2** for basic socioeconomic and demographic indicators).

History

After declaring independence from the Spanish empire in 1821 and from the Mexican empire in 1823, Honduras struggled to make progress in social, economic, and political development. In the late 19th

Ken Hashimoto and Joseph Rhatigan prepared this case with assistance from Hisham Yousif for the purpose of classroom discussion rather than to illustrate either effective or ineffective health care delivery practice.

century, US-based infrastructure and fruit-growing companies established themselves in northern Honduras but did little to contribute to economic growth of the country.

After military government rule from 1963 to 1981, the first presidential election took place in 1982. During the 1980s, the country received annual economic and US military aid of over USD 100 million. Foreign aid between 1985 and 1989 represented about 4.6% of Honduras's GDP.

In 1998, Hurricane Mitch destroyed about 70% of the crops and an estimated 70–80% of the transportation infrastructure, including most bridges and secondary roads.[3,4] Across the country, 33,000 houses were destroyed and an additional 50,000 damaged; some 5,000 people were killed and 12,000 more were injured. Total losses were estimated at USD 3 billion.[3,4] Hurricane Mitch further increased the presence of international donor agencies; the World Food Programme (WFP), the Pan American Health Organization (PAHO), and UNICEF, and many individual countries, delivered emergency food, sanitation, and medical equipment; the Inter-American Development bank offered almost USD 200 million in rebuilding loans.[5]

In 2012, 66.5% of the Honduran population fell below the national poverty line (USD 2/day).[6] Seventy-five percent of the rural population, including indigenous groups, lived in the country's interior highlands; half of them lived in extreme poverty.[7] Many lacked access to land and basic services. In 2012, 82% of rural Hondurans had access to an improved source of water.[1] Scarce employment opportunities in rural areas caused high emigration.

Health System

Three sectors provided health care in Honduras: The Ministry of Health served approximately 50% of the population; the Social Security Institute, 12%; and private providers, the remainder. The Ministry of Health was the only entity that provided preventive health care in communities (see **Exhibit 3** for health system and epidemiologic indicators).

In 1990, the Ministry of Health began health sector reform to strengthen primary health care by augmenting the number of health centers and posts, training more community volunteers, and integrating disease-specific programs. As a result, four programs—vector control, zoonosis, basic sanitation, and food security—were combined to form the Environmental Health Program.

The Ministry of Health established the National Chagas Program in 1994. The program included the Vector Transmitted Disease Division, whose activities consisted of vector search and control in endemic areas, clinical studies for disease characterization, community education, and the promotion of dwelling improvement. In addition, the National Chagas Program worked to strengthen policy related to Chagas eradication.[8] In 2004, it released a national Chagas control plan.

Chagas Disease and Early Control Efforts

Disease, Transmission, and Interventions

Chagas disease (American trypanosomiasis) was caused by the protozoan *Trypanosoma cruzi*.[6] An estimated 7 million people were infected worldwide, predominately in Latin America. More than 80% of Chagas disease infection was transmitted by the insect vectors of subfamily triatominae, commonly known as kissing bugs or assassin bugs. Main vectors in Central America were *Rhodnius prolixus* and *Triatoma dimidiata* (see **Exhibit 4** for images of Chagas vectors). These insects lived in cracks in mud walls and thatched roofs of houses, mostly found in poor rural areas. Transmission was relatively low, but inhabitants were continually exposed to the vectors. *R. prolixus* were more efficient in transmitting the parasite. Their habitat was limited to dwellings, which made them a candidate for elimination. *T. dimidiata* were less infectious, but lived both inside and outside dwellings, including the natural environment, and thus could not be eliminated. Chagas disease could also be transmitted through pregnancy (3–-5% chance of mother-to-child transmission), blood transfusions with infected blood, ingestion of contaminated food or drinks, and laboratory accidents.

During the acute phase of infection, patients were often asymptomatic. In 5% of acute infections, patients presented symptoms including fever, fatigue, and inflammation of an eye or a bitten area. During the acute phase, the parasite was widely distributed throughout the bloodstream and eventually infiltrated tissues, especially the heart and gastrointestinal tract.

Serological tests, which detected antibodies, could diagnose the disease (parasites were often too few to find in blood samples by microscopy). Chagas disease was curable as long as those infected had access to antiparasitic drugs (nifurtimox and benznidazole) shortly after contracting it. However, due to the lack of acute symptoms, many patients were left undiagnosed until significant organ damage had occurred. If left untreated, the *T. cruzi* infection became chronic. After 15–20 years, 30% of those infected with chronic *T. cruzi* infection developed cardiac complications such as heart failure or arrhythmias, and 10% developed gastrointestinal or neurological symptoms such as dilation of the esophagus or colon.

The parasite *T. cruzi* infected not only humans but also domestic and wild animals, and therefore had a large non-human reservoir. The primary strategy for reducing Chagas disease transmission was vector search and vector control. Vector search techniques included scanning structures for triatomminae insects or fecal matter; however, this technique had a large margin for error and necessitated repetition to produce more accurate results.[9] Indoor residual spraying (IRS) of insecticide and house improvement could eliminate or reduce the risk of vector infestation. As with strategies to control malaria and other insect-born diseases, Chagas disease vector control consisted of three phases:

1. The preparatory phase established a baseline by entomological and serological surveys
2. The attack phase eliminated vector infestation by extensive IRS campaigns
3. The surveillance phase minimized vector reinfestation by community-based surveillance

Sporadic Investigations and Projects: 1970–2002

A decade after discovery of the first Chagas disease case in 1960, Honduran investigators began research on disease prevalence. In 1972, a study found a seroprevalence of 37% among 304 individuals living in houses with mud walls and thatched roofs. A national survey in 1983–1984 revealed a seroprevalence and household vector infestation* of 15.2% and 15.6%, respectively, in the most highly affected region; 4.4% and 3.6% in the average risk areas; and a seroprevalence of 0.2% in areas with no vector infestation (see **Exhibit 5** for a map of seroprevalence and household vector infestation in Honduras).

From 1991 to 1994, the National Chagas Laboratory found a seroprevalence of 13% among 674 pregnant women and of 1.9% among 3,229 children under five in two districts in southern Honduras. The household vector infestation was 25.0% (1,103/4,411) in 288 villages.

Although Chagas disease was less known among the Honduran population in the late 1990s, estimated seroprevalence was more than four times that of HIV/AIDS (see **Exhibit 6** for rates of new HIV, TB, and malaria infection between 1990 and 2010).

* (Number of households infested with vectors / number of households surveyed) x 100

In the three years following Hurricane Mitch, Médecins Sans Frontières (MSF) implemented Chagas disease control projects in two areas in Central North. Joint vector control and medical care efforts with local health services contributed to disease reduction in the selected areas, however they did not involve the National Chagas Program.

Regional Initiative for Chagas Disease Control

The success of the South American Initiative for Chagas Disease Control[†], formed in 1991, led to the establishment of the Central American Initiative for Chagas Disease Control (IPCA)[‡] in 1997. Both initiatives had PAHO/WHO as technical secretary and aimed to interrupt disease transmission by vectors and blood transfusion by the year 2010. Interruption of transmission from vectors to hosts was a key strategy toward eventual elimination—i.e., the reduction of Chagas incidence to zero in the region.[10]

To this end, IPCA evaluated the progress of the member countries by organizing annual meetings and dispatching international missions; produced technical guidelines and criteria for certification of interruption of Chagas disease transmission; and certified the countries for achieving the goals.

JICA's Infectious Disease Projects in Central America

The Japan International Cooperation Agency (JICA), an independent government agency founded in 1974, provided technical cooperation, loan assistance, and aid to over 150 countries in 2012.[11] JICA's key mission was to achieve human security from civil strife, disasters, poverty, and other humanitarian threats, including infectious diseases, by supporting efforts to bolster social and institutional capacity and to increase communities' ability to deal with these threats themselves.

Some of JICA's first health projects aimed to address onchocerciasis in Guatemala in the 1970s and 1980s through vector control. Success led to further efforts in Guatemala, including Chagas disease control.[12] Collaborating with various Guatemalan universities and the Guatemalan Ministry of Health, JICA mapped Chagas vector distribution, developed efficient survey methods, documented safe and effective insecticides, and measured seroprevalence in highly infested regions. A JICA senior adviser then designed a Chagas control project for the departments with the highest rates of disease. The project aligned the Ministry of Health, PAHO/WHO, and JICA; it bolstered political, technical, managerial and operational components by encouraging collaboration, co-investment, and mutual monitoring (see **Exhibit 7** for more information on the triangular alliance). Although the Ministry of Health was responsible for operational costs, JICA project and field coordinators worked in the National Chagas Program and departmental health offices and helped to strengthen communication between these offices and the management of interventions, data, and materials.

By 2002, Guatemala had considerably reduced house infestation rates of *R. prolixus* by more than 50% after one spraying. This drew attention from other Central American countries in the IPCA annual meetings.[10] Shortly afterward, Honduras and El Salvador engaged JICA in their Chagas disease efforts.

Honduras Program, 2003–2007: Preparatory and Attack Phases

Designing the Project Model

† Member countries: Argentina, Bolivia, Brazil, Chile, Paraguay, and Uruguay.
‡ Member countries: Belize, Guatemala, Honduras, El Salvador, Nicaragua, Costa Rica, and Panama.

In September 2003, the Honduran Ministry of Health and JICA launched the Chagas control program in four heavily affected departments (see **Exhibit 8** for a map of departments) in the western region bordering Guatemala and El Salvador. Chagas disease control was new for most personnel of the Ministry of Health. They employed the same two cooperation strategies implemented in Guatemala: a tripartite alliance between Ministry of Health, PAHO/WHO and JICA, with JICA coordinators installed at the national and departmental levels (see **Exhibit 9** for an organizational chart of the Honduran Ministry of Health).

Dr. Concepción Zúniga, a 40-year-old physician with a Master's degree in parasitology and chief of the National Chagas Program of the Ministry of Health in Honduras, welcomed JICA's Michio Kojima. Kojima, a 29-year-old Japanese project coordinator, had worked in Guatemala as a JICA program officer in a departmental education office for promoting Chagas disease prevention at schools. Dr. Zúniga and Kojima organized a trip to Guatemala so the Honduran team could observe Chagas disease control activities, including IRS, a vector search survey, data management, and serological diagnostics by Guatemalan technicians. The Hondurans who had worked with malaria vector control found the Chagas interventions familiar.

Although motivated by their trip, the team found significant challenges at home. The Guatemalan model relied heavily on operational personnel for the survey and IRS. Budget constraints in the Honduran Ministry of Health critically limited human resources. Most environmental health technicians there worked at the operational level rather than in the field and had multiple responsibilities. In the department of Lempira, for example, eight technicians were responsible for over 30,000 mud-walled houses.

When an IPCA evaluation mission visited Honduras to assess progress toward the regional goal a few months after the Chagas Program was launched, it concluded that the program had yet to address fundamental needs, including production of baseline data, stratification of risk areas, establishment of objectives and plans, construction of information system, and acquisition of resources.

In response, Dr. Zúniga wrote a long-term plan for the National Chagas Program. He invited stakeholders from multiple sectors and entities, including the National Chagas Laboratory, National Entomology Unit, PAHO/WHO, JICA, the Canadian International Cooperation Agency (CIDA), and World Vision, among others, to participatory workshops to produce the National Strategy Plan 2003–2007. The plan described the objectives, activities, indicators, and estimated costs for each activity, as well as roles of participating programs of the Ministry of Health and donors. At Dr. Zúniga's urging, the president of Honduras launched the National Strategy Plan in the presence of directors of key institutions and programs and received significant media coverage.

Adapting the Honduran Method

The National Chagas Program and National Chagas Laboratory, with assistance from donors, wrote the national standards for Chagas disease control based on IPCA technical guidelines. In early 2004, the National Chagas Program and its partners conducted a trial in San Francisco de Opalaca, a mountainous area with numerous houses with thatched roofs and a history of infestation of both species of vectors (*R. prolixus* and *T. dimidiata)* documented by World Vision. The local health center had a good relationship with the key stakeholders: the municipality, schools, World Vision, and the communities.

Fifteen sprayers were selected from different communities and trained for two days by environmental health technicians (see **Exhibit 4** for images of IRS training). In one month, a total of 2,187 households in 31 villages were sprayed. The pilot IRS campaign used reports from the inhabitants and sprayers to identify 11 villages with *R. prolixus*, the more infectious vector. The Ministry of Health and donors visited the trial sites and confirmed the effectiveness of the model.

Yet the Ministry of Health needed a more efficient and systematic method to identify risk areas throughout the country. Because their numbers were limited, operational personnel could not regularly visit villages as the Guatemalan model suggested. Therefore, Dr. Zúniga's team created a simplified risk area detection method consisting of "entomological exploration" (traveling to primary schools to distribute images of vector bugs in classrooms and ask children if they had seen the bugs in their houses) and "serological exploration" (systematically sampling 30 students in each primary school in potential risk areas using a rapid, 15-minute serological diagnostic test).

After a series of trials, the Ministry of Health found that entomological exploration was not effective: The children lacked the skills to search for vectors and or to differentiate vectors from other similar bugs. The rapid serological diagnostic tests, however, identified hot spots, especially when over 20% of children were positive. In the identified highly affected areas, the Ministry of Health organized a further serological survey targeting all children under the age of 15, collecting blood samples on filter paper and sending them to the National Chagas Laboratory. Those who tested positive were treated with antiparasitic drugs (nifurtimox or benznidazole) under the surveillance of clinical staff at local health centers and community volunteers who assessed seropositivity again at 18 and 36 months post-treatment.

Early Trial Results

In 2003, with the technical and financial assistance of JICA, the National Chagas Program began hosting quarterly evaluation meetings. At that time, Kojima was based six hours away from the capital city Tegucigalpa; in 2004, he moved to Tegucigalpa to facilitate coordination with the central level of the Ministry of Health, where he shared a desk with Dr. Zúniga.

Dr. Zúniga's consistent and strategic negotiations with the human resources office of the Ministry of Health brought the Chagas Program an office and more personnel. Beginning in 2005, the evaluation meetings became biannual to reduce costs and workload, and by 2007, a total of 13 departments took part in the meetings. By that time, the national program was staffed with two technicians, a health promoter, an information officer, an administrator, and a secretary.

Dr. Zúniga led a roundtable with the governmental programs and donors involved in Chagas disease control to share information and discuss relevant issues. Every two to three months, a different roundtable member hosted. This rotation of meeting places gave the hosts an opportunity to invite their bosses and colleagues. By 2007, the roundtable grew to include more sectors and NGOs that supported vector control or carried out house improvement projects in specific areas.

Between 2003 and 2007, the Honduran Ministry of Health sprayed a total of 116,516 households in 14 departments and identified 206 villages infested with *R. prolixus*. In eight departments, 4.3% (830/19,286) of children were diagnosed positive and treated. The work cost USD 3.6 million, of which USD 0.8 million was invested by the Honduran Ministry of Health and the rest by JICA (see **Exhibit 10** for the project budget).

Honduras Program, 2008-2011: Surveillance Phase

Reframing the Approach

Chagas disease infection risks diminished through IRS campaigns, almost eliminating *R. prolixus* from Honduras. However, reemergence of the vector was a risk. To prevent this, the Honduran Ministry of Health and JICA began the second phase of the project in 2008 with the aim of establishing and scaling up a surveillance model to minimize reinfestation with vectors, especially *T. dimidiata,* the widespread non-eliminable vector that lived in the peridomestic and natural environment.

The project also extended target areas from four to eight departments and allocated two new JICA advisers to succeed Kojima at the National Chagas Program and new JICA field coordinators to departmental health offices. The JICA advisers had management experience but no medical or entomological backgrounds. With project coordination mechanisms in place, they focused on technical assistance. One adviser, an experienced administrator, was placed in the National Chagas Program office in Tegucigalpa to oversee the general progress of the project, and the other, who specialized in vector control management, was placed in the departmental health office of Copán to help build a surveillance system.

The surveillance model featured a "notification response" mechanism; community members would notify health officials of a residential bug infestation and the local health services would respond with insecticide spraying or measures residents could take to prevent future indoor infestations. Consistent notification response would minimize reinfestation of vectors and consequently, disease infection risks.

The Ministry of Health officials and JICA advisers often had different opinions about the pace of program management and the level of risk they were willing to tolerate. In general, Honduran officials advocated for careful progress, while JICA advisers felt that implementing and scaling up the program was urgently needed and should be done as quickly as possible.

Ministry of Health officials had to get used to their new role in the program. Previously, department coordinators managed the response to community notification of infestations as part of periodic IRS campaigns. In the newly configured program, for the surveillance phase, *local* health centers would respond to community notifications of infestation. Now the departmental health officers had to transform themselves from mangers to monitors, transferring the managerial role to the local health center staff.

In June 2008, the National Chagas Program and JICA organized a biannual evaluation. After the 13 departments reported on their progress, JICA's technical adviser explained the project plan, the basic concept of community-based surveillance, and the local health center role. Dr. Zúniga raised his concerns about the negative environmental effects and reduced efficacy of ongoing IRS and proposed using community education to control *T. dimidiata.* The chief of the National Chagas Laboratory supported Dr. Zúniga. However, JICA's technical adviser questioned the efficacy of treatment that relied solely on community education. He also pointed out that spraying against *T. dimidiata* had long been common practice in Honduras.

This interaction in front of more than 50 departmental staff made Dr. Zúniga and the National Chagas Laboratory chief more resolute in their positions and created tension between the Honduran Ministry of Health and JICA. The Honduran Ministry of Health was ultimately responsible for deciding on the project's strategy.

Reconceptualizing Surveillance

In July 2008, JICA's project management team organized a workshop to sketch a blueprint of the community-based surveillance initiative, inviting technical staff from the National Chagas Program, National Chagas Laboratory, Medical Entomology Unit, and donors. The Ministry of Health's efforts had limited surveillance to vector notification by community members. JICA's technical adviser now presented an example of a surveillance model that suggested engagement at the central, departmental, municipal, and community levels. Yet no discussion followed.

The following month, a second workshop was held with the same participants. This time, technicians from the Ministry of Health began voicing their opinions. They eventually decided to spray when nymphs of *T. dimidiata* were found inside households, which indicated colonization in the dwelling. The workshop led to the creation of a pilot surveillance model that would be trialed in six sites.

Designing a Practical Surveillance Model Through Trials

Technicians of departmental health offices and the National Chagas Program monitored surveillance trials during field visits and presented updates at quarterly review workshops.

When the trials began, Dr. Zúniga was skeptical about the health centers' capability to manage Chagas disease vector surveillance; more decentralization meant less control over the performance and the quality of operational activities. However, over time, he gained trust in health center staff capabilities and became convinced that surveillance could be managed locally when monitored by departmental technicians.

During 2010–2011, the National Chagas Program produced new national guidelines for Chagas disease surveillance through a series of nine workshops with other collaborating programs and units of the Ministry of Health and donors. In addition, the National Chagas Program and JICA introduced a monitoring checklist of 48 items, including essential tasks for the National Program (11 items), departmental health offices (12 items), health centers (14 items), and communities (11 items) to track in the six pilot sites. As a result, the average performance score improved from 46% in March 2009 to 84% in February 2011.

Scaling up the Surveillance Model

With apparent success, the National Chagas Program scaled up the surveillance model to other departments, each piloting one site to start with. Required resources included educational materials, notification-response registry books, and insecticides. No extra staff was required. By 2011, 88 municipalities in eight departments had a Chagas disease surveillance system. Progress was monitored through biannual evaluation meetings and bimonthly roundtable meetings by the National Chagas Program, other national programs, institutions, and donors. From 2008 to 2011, the Honduran Ministry of Health spent USD 0.5 million and JICA, USD 2 million (see **Exhibit 10**).

Results of Vector Control Interventions

A PAHO/WHO consultant who evaluated the Honduran Ministry of Health Chagas Program in 2008 had revealed that the number of serological samples were insufficient. To overcome this limitation, Dr. Zúniga advocated—to top Ministry of Health and departmental health officials—for carrying out adequate numbers of serological surveys, emphasizing the political significance of the international certification. Neighboring Guatemala's 2008 certification further encouraged the Honduran Ministry of Health.

Later serological surveys revealed that the seroprevalence among children under 15 years of age in extensive endemic areas of the country declined from 3.6% (972/26,925) in 2004–2007 to 0.5% (173/37,441) in 2009–2011. These results led to international certification of interruption of Chagas disease transmission by *R. prolixus* in 2011.

JICA's Exit, 2012–2014

To ensure the continued success after JICA's transition out of Honduras, the bilateral project team identified and agreed on five key activities to be included in the National Chagas Program agenda (see **Exhibit 11** for a conceptual projection of JICA's exit strategy in Honduras):

1. Field monitoring of community-based surveillance
2. The use of an information system built with assistance of PAHO/WHO for systematic analysis
3. Annual celebration of the Central American Chagas Day on July 9 to generate impetus at the national level

4. Organization of biannual evaluations with the departmental health offices to monitor, advance, and communicate experiences
5. Bimonthly roundtable meetings to revise issues related to the national strategies and international agendas

JICA's Transition in Central America

By the time JICA was ready to leave Honduras, it had also engaged in El Salvador and Nicaragua. JICA worked with each ministry of health to document achievements and best practices to help health professionals at the managerial and technical levels overcome challenges in Chagas disease control. The chief of the National Chagas Program in each country and the JICA regional adviser presented the document and discussed the content through workshops at national and local levels.

Between 1990 and 2010, the prevalence of Chagas disease in Guatemala, Honduras, El Salvador, and Nicaragua fell by 75%, from 1.4 million to 0.4 million, and annual incidence declined by 93%, from 53,100 to 3,600 (see **Exhibit 12** for estimated change in Chagas prevalence and incidence).[13–15] Additionally, IPCA–PAHO/WHO certified the interruption of Chagas disease transmission by the principal insect vector *R. prolixus* in Guatemala (2008), Honduras (2011) and Nicaragua (2011). El Salvador was certified for elimination of the vector in 2010.

New Leadership, Challenges, and Opportunities

Organizational Changes in Honduras

Although the subsequent goals and steps were clear as projected by the Second Strategic Plan of the National Chagas Program 2008–2015 (implementation of community-based surveillance of *T. dimidiata*, detection and treatment of patients, as well as house improvement throughout the country), in 2012, Dr. Zúniga was transferred to another office within the Ministry of Health. The CIDA continued supporting the Honduran Ministry of Health's Chagas disease control program with an enlarged grant of approximately USD 15 million from 2012 to 2017. The roundtable was appointed as an official board to assess and approve the project's annual operation plans. In addition, financial administration was shifted from the National Chagas Program to the departmental health offices.

Fight Against the Non-Eliminable Vector, T. dimidiata

The more efficient vector, *R. prolixus*, was almost eliminated in Honduras; however, the other main vector, *T. dimidiata*, remained a threat throughout the region, though to a lesser degree. To prevent colonization of vectors, the University of San Carlos of Guatemala developed a cost-effective method to plaster mud walls and floors using locally available materials. It shared the approach with other Central American countries through IPCA meetings and local workshops. The Ministries of Health of Honduras, Guatemala, Nicaragua, and El Salvador incorporated the house improvement method and continued searching for strategies to sustain community prevention methods and to overcome the lack of personnel in rural communities.

Having almost achieved the *R. prolixus* elimination goal in Central America, the countries wanted to agree on a new set of long-term strategies to sustain efforts to control *T. dimidiata* throughout the isthmus. Meanwhile, due to the success of the programs, PAHO/WHO's funding for Chagas disease was reduced. What could Dr. Zúniga advise, given what he had learned from his time at the helm, that would help maintain the program's momentum?

Appendix *Common Acronyms and Abbreviations*

CIDA	Canadian International Development Agency (CIDA)
IRS	Indoor residual spraying
IPCA	Central American Initiative for Chagas Disease Control (Intergovernmental Commission for the Central American Initiative for Interruption of the Vector and Transfusion Transmission of Chagas Disease)
JICA	Japan International Cooperation Agency
PAHO	Pan American Health Organization
T. dimidiata	*Triatoma dimidiata*
R. prolixus	*Rhodnius prolixus*
WFP	World Food Programme

Exhibit 1 *Map of Honduras*

Source: United Nations Geospacial Information Section.

Exhibit 2 *Basic Socioeconomic and Demographic Indicators*

INDICATOR		YEAR
UN Human Development Index ranking	131 (out of 188)	2014
Population (thousands)	7,736	2012
Urban population (%)	53	2012
Drinking water coverage (%)	90	2012
Poverty rate (% living under USD 1.90 per day)	21.4	2012
Gini index	53.7	2013
GDP per capita in PPP (current international $)	4,926.6	2014
GDP per capita (current USD)	2,434.3	2014
Literacy (total/female/male)	88.5/88.6/88.4	2015

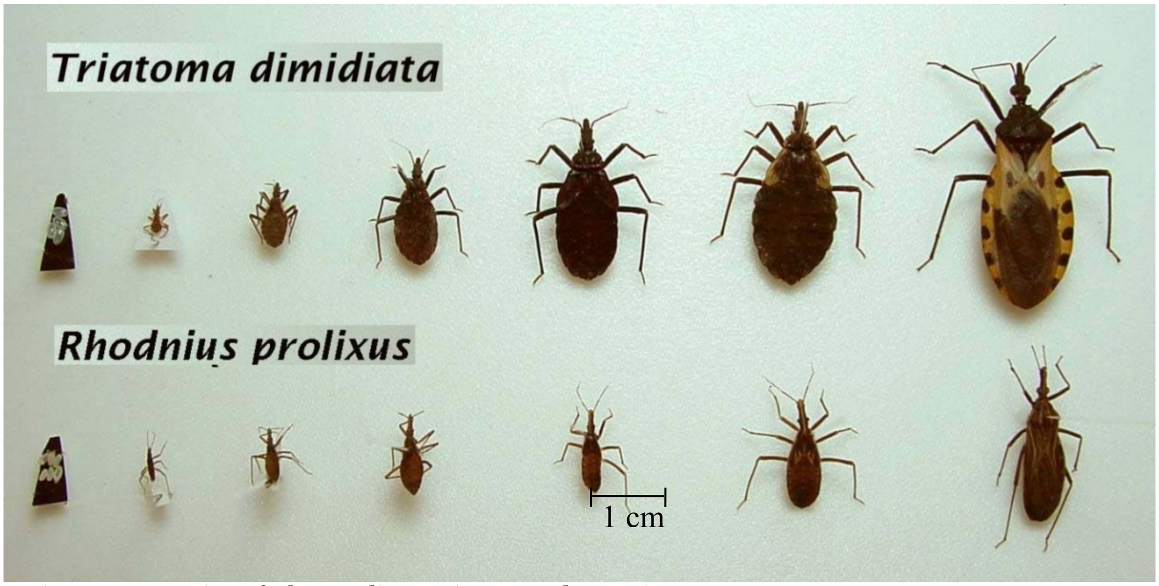
Source: Compiled by case writers using data from the United Nations, UNICEF, World Bank, and the International Monetary Fund.

Exhibit 3 *Health System and Epidemiologic Indicators*

INDICATOR		YEAR
Average life expectancy at birth (total/female/male)	73.1/75.7/70.7	2014
Maternal mortality ratio (per 100,000 live births)	141	2012
Under-five mortality (per 1,000 live births)	22	2013
Infant mortality rate (per 1,000 live births)	17	2014
Vaccination rates (% of DTP3 coverage)	87	2013
Undernourished (%)	13.7	2013
Adult (15–49 years) HIV prevalence (%)	0.4	2014
HIV antiretroviral therapy coverage (%)	58	2012
Tuberculosis prevalence (per 100,000)	43	2014
DOTS coverage (%)	100	2006
Malaria cases (per 100,000)	377	2012
Government expenditure on health as % of total government expenditure	15.4	2014
Government expenditure on health per capita (PPP international dollars/USD)	400/212	2014
Total health expenditure per capita (current USD)	212	2014
Physician density (per 10,000)	.372	2005
Nursing and midwifery density (per 10,000)	1.082	2005
Number of hospital beds (per 10,000)	7	2012

Source: Compiled by case writers using data from WHO, World Bank, PEPFAR, UNICEF, WHO, GAVI, STOP TB, and UNFPA. Data represent latest available as of 2015.

Exhibit 4 *Vector Bugs and Indoor Residual Spraying*

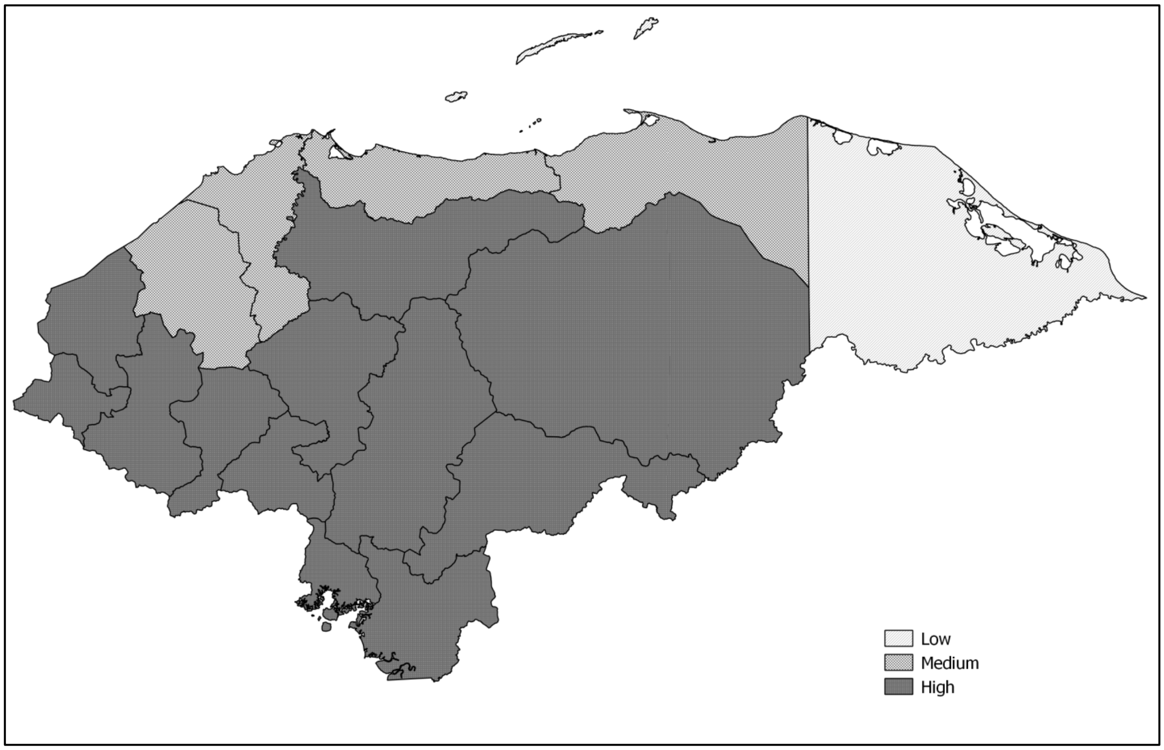


Main vector species of Chagas disease in Central America.


Training community members for indoor residual spraying in the first trial in Intibucá 2004.

Source: (Vector chart) Biblioteca Virtual en Salud de Honduras. (Photo) Case writers.

Exhibit 5 *Chagas Disease Seroprevalence and Household Infestation of Vectors in Honduras, 1983–1984*



Risk levels	Departments	Prevalence among population (%)	Household infestation of vectors (%)
High	Comayagua, Copán, Choluteca, El Paraíso, Francisco Morazán, Intibucá, La Paz, Lempira, Ocotepeque, Olancho, Valle, and Yoro	15.6	15.2
Medium	Atlántida, Colón, Cortés, and Santa Bárbara	4.4	3.6
Low	Gracias a Dios and Islas de la Bahía	0.2	0

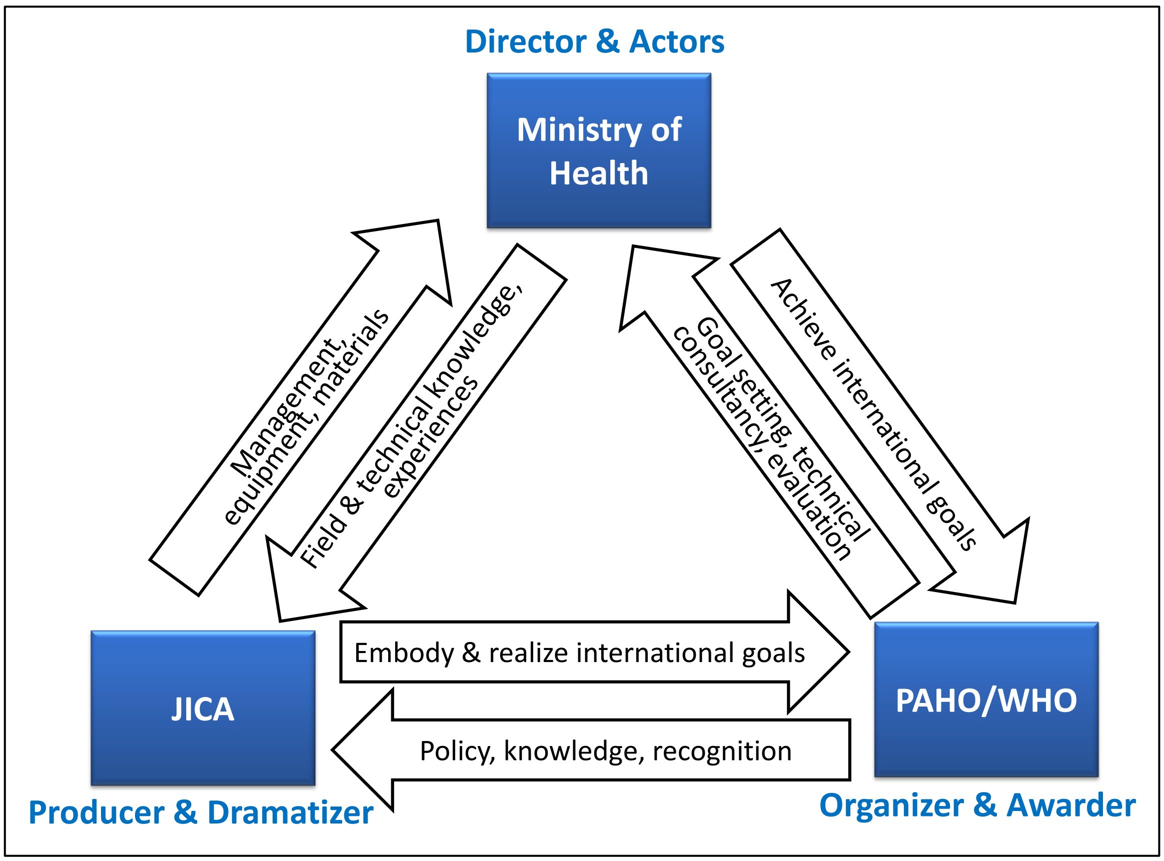
Source: Ponce C. 1986. Final report: A study of Chagas disease prevalence in Honduras. Ministry of Health Honduras (in Spanish). Tegucigalpa.

Exhibit 6 *HIV, Tuberculosis, and Malaria in Honduras over Three Decades*

Disease	Incidence			Prevalence		
	1990	2000	2010	1990	2000	2010
HIV/AIDS	5,877	2,914	950	18,819	44,562	32,433
Tuberculosis	3,647	6,406	2,876	8,700	11,000	6,400
Malaria	53,000	35,125	9,684	53,000	35,125	9,684

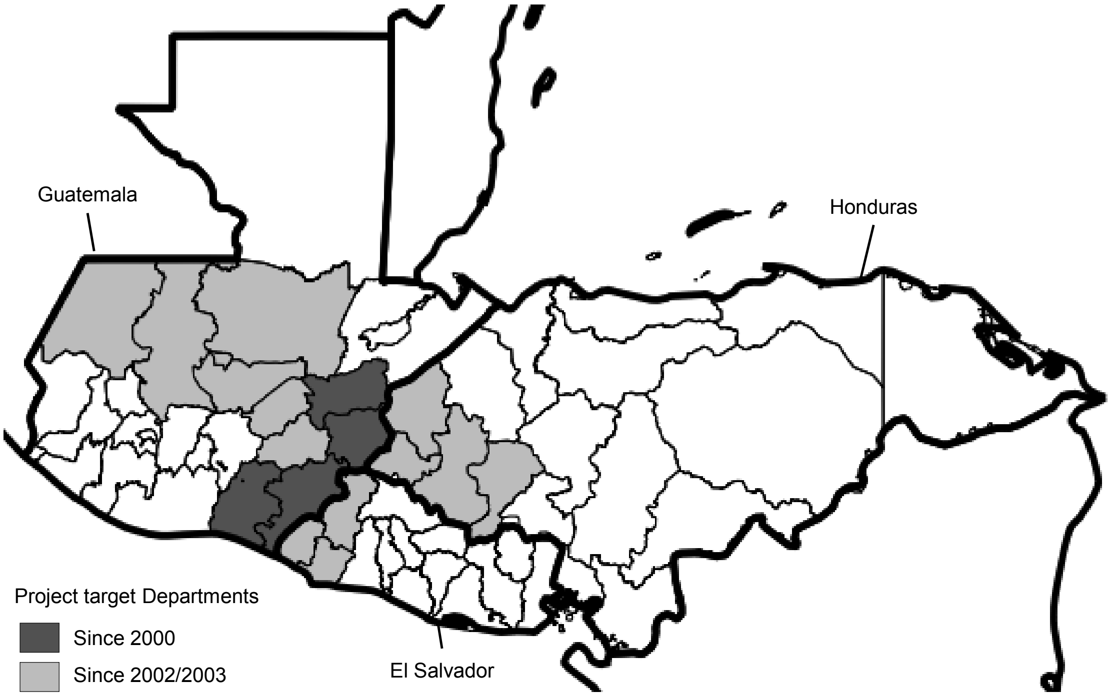
Source: United Nations Data.

Exhibit 7 Chagas Control Project: *Roles of Ministry of Health, PAHO/WHO, and JICA*



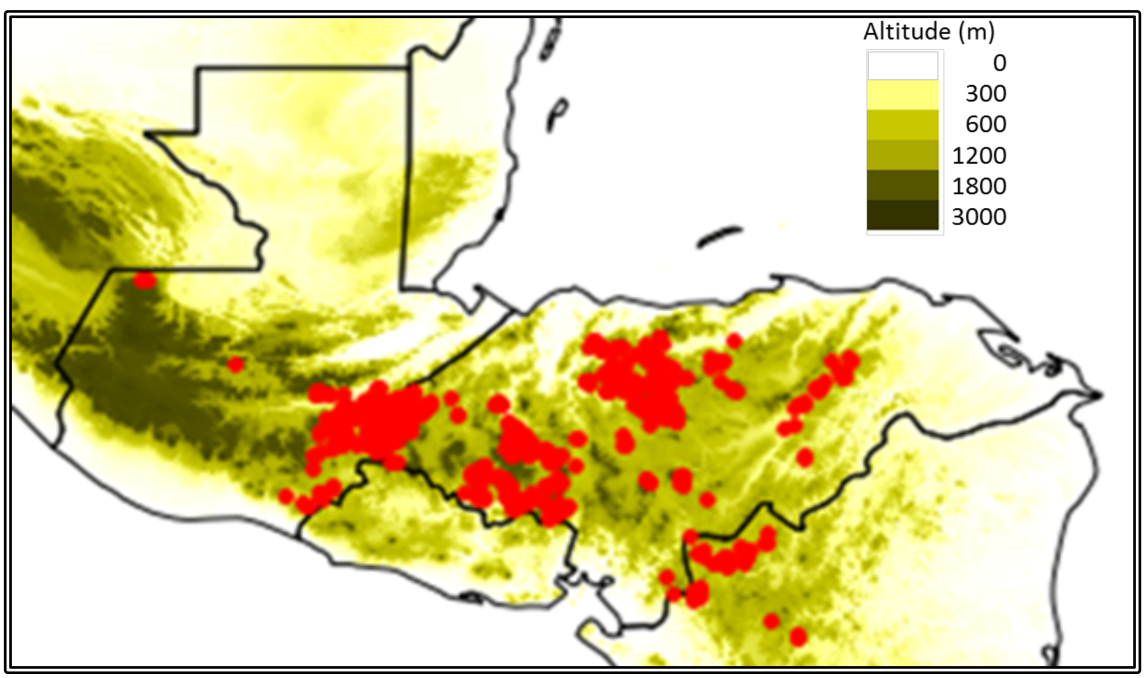
Source: Hashimoto K. 2015. Control of Chagas Disease Control in Central America—A Japanese Perspective (in Spanish). Japan International Cooperation Agency. Tegucigalpa.

Exhibit 8a *Target Areas of Guatemala, Honduras, and El Salvador, 2000–2003*



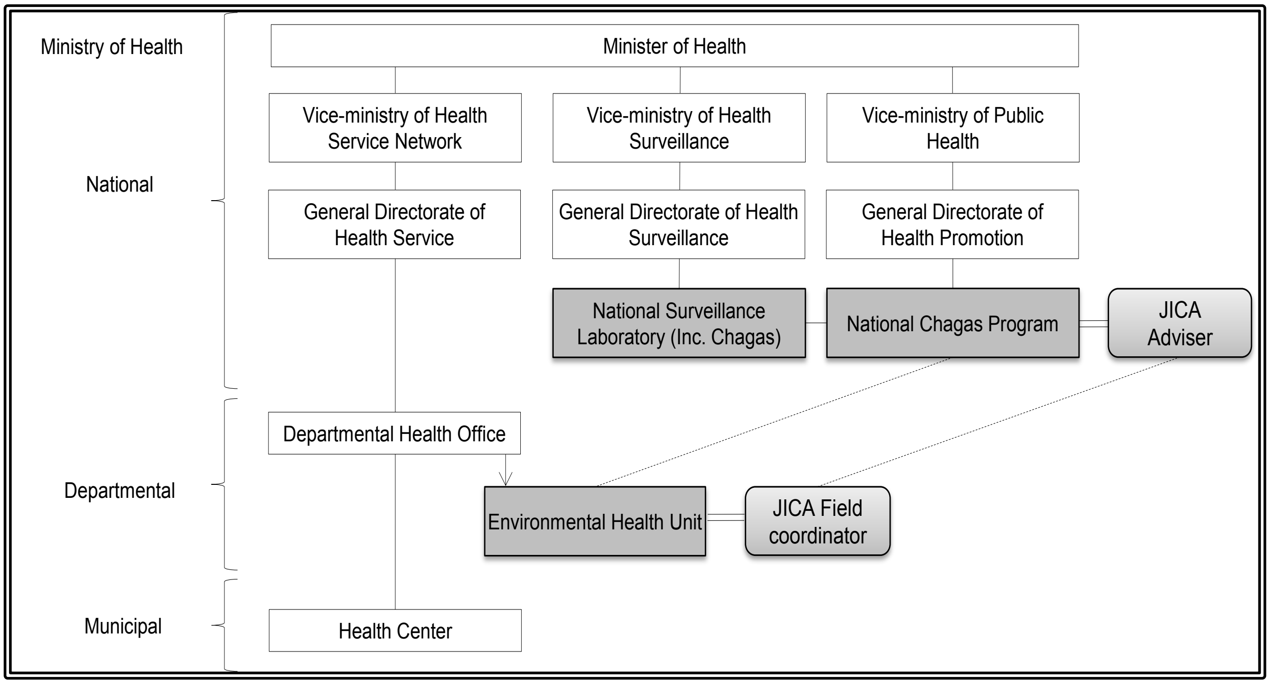
Source: Hashimoto K. 2015. Control of Chagas Disease Control in Central America—A Japanese Perspective (in Spanish). Japan International Cooperation Agency. Tegucigalpa.

Exhibit 8b *Villages Infested by* R. prolixus*, 1997–2012*



Source: JICA. 2014. Best practices from the Chagas disease control in Guatemala, El Salvador, Honduras and Nicaragua 2000–2014 (original in Spanish, summary in English). Tegucigalpa.

Exhibit 9 *Simplified Organizational Chart of the Honduran Ministry of Health*



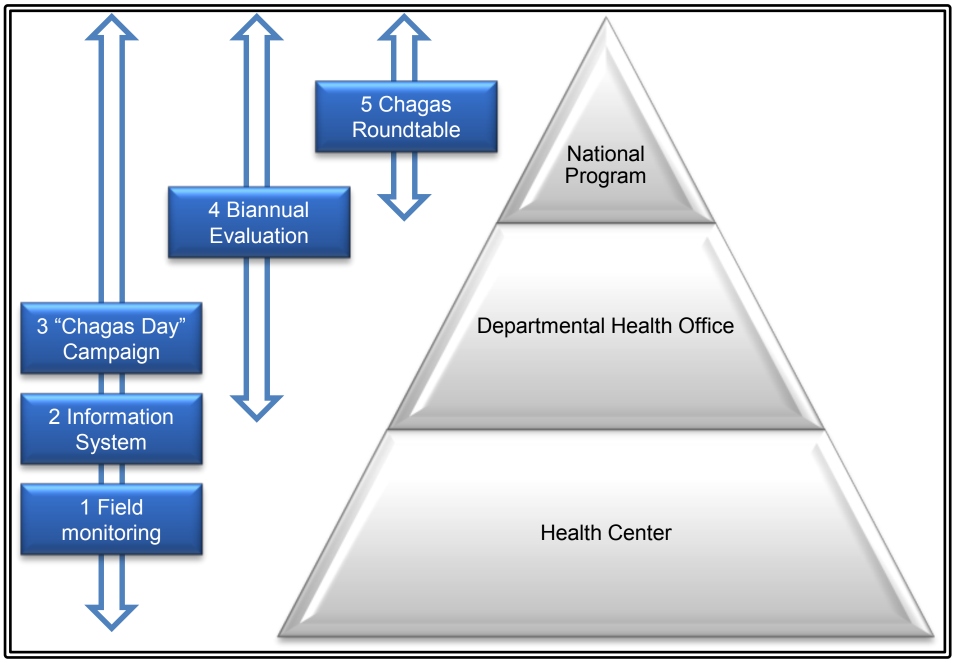
Source: Hashimoto K. 2015. Control of Chagas Disease Control in Central America—A Japanese Perspective (in Spanish). Japan International Cooperation Agency. Tegucigalpa.

Exhibit 10 *Budgets of the Bilateral Projects (USD)*

Project	Stakeholder	Total
Phase I: 2003–2007	Ministry of Health, Honduras	780,000
	JICA	2,820,000
	TOTAL	**3,600,000**
Phase II: 2008–2011	Ministry of Health, Honduras	450,400
	JICA	2,040,877
	TOTAL	**2,491,277**

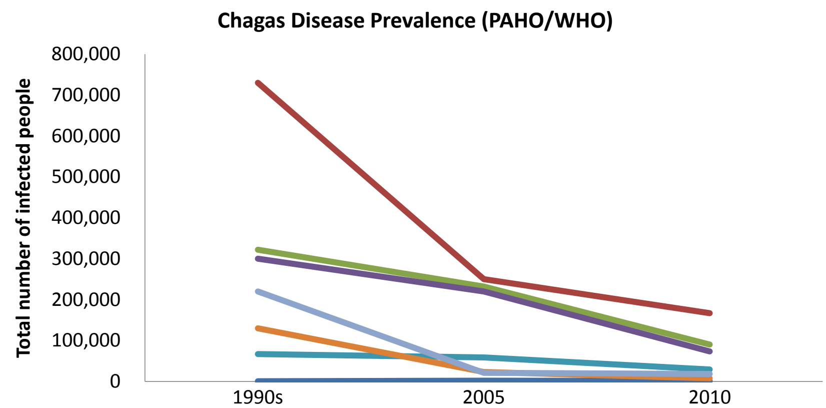
Note: Costs include equipment and materials (including those from Japan), as well as operational costs.
Source: JICA. Project Evaluation Reports: 2007 and 2011.

Exhibit 11 *Conceptual Projection of the JICA's Exit Strategy in Honduras*

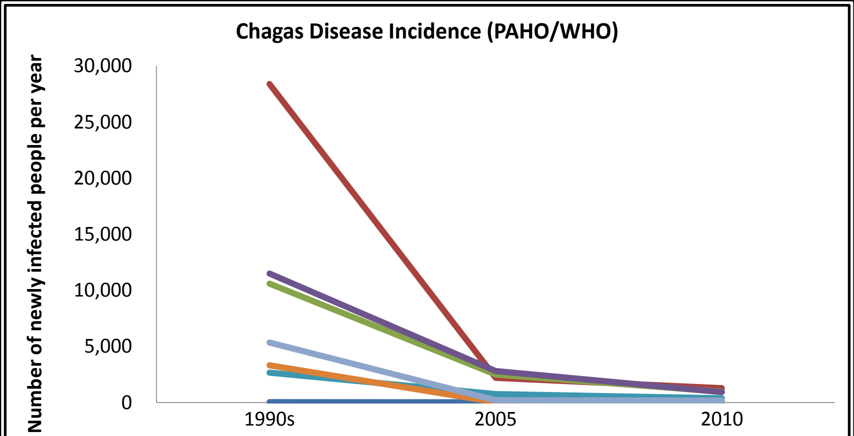


Source: JICA. Final report: Chagas disease control project Phase 2, 2008–2011 (in Spanish). 2011.

Exhibit 12 *Changes in Estimated Prevalence and Incidence of Chagas Disease*



	1990s	2005	2010
Belize	600	2,000	1,040
Guatemala	730,000	250,000	166,667
El Salvador	322,000	232,000	90,222
Honduras	300,000	220,000	73,333
Nicaragua	67,000	58,600	29,300
Costa Rica	130,000	23,000	7,667
Panama	220,000	21,000	18,337



	1990s	2005	2010
Belize	26	20	10
Guatemala	28,387	2,200	1,275
El Salvador	10,594	2,500	972
Honduras	11,490	2,800	933
Nicaragua	2,660	750	383
Costa Rica	3,320	30	10
Panama	5,346	200	175

Sources: World Health Organization. Control of Chagas Disease: Second Report of the WHO Expert Committee. Geneva: World Health Organization; 2002.

PAHO/WHO. 2006. Estimación Cuantitativa de la Enfermedad de Chagas en las Américas. OrganizaciónPanamericana de la Salud. WHO/NTD/IDM.OPS/HDM/CD/425-06.

WHO. 2002. Control of Chagas Disease. Second report of the WHO Expert Committee. WHO Technical Report Series; 905. World Health Organization. Geneva.

References

1. The World Bank. Honduras Data. The World Bank. http://data.worldbank.org/country/honduras. Published 2016. Accessed September 13, 2016.
2. Central Intelligence Agency. The World Factbook—Honduras. The World Factbook. https://www.cia.gov/library/publications/the-world-factbook/geos/ho.html. Published 2016. Accessed September 13, 2016.
3. BBC. Honduras Country Profile. BBC News. http://news.bbc.co.uk/2/hi/americas/country_profiles/1225416.stm. Published 2012. Accessed September 14, 2016.
4. BBC. Honduras Timeline. BBC World Service. http://news.bbc.co.uk/2/hi/americas/country_profiles/1225471.stm. Accessed September 14, 2016.
5. United Nations Economic Commission for Latin America and the Caribbean. *Honduras: Assessment of the Damage Caused by Hurricane Mitch, 1998: Implications for Economic and Social Development and for the Environment*. Santiago: United Nations Economic Commission for Latin America and the Caribbean; 1999. http://www.cepal.org/publicaciones/xml/6/15506/L367-1-EN.pdf. Accessed October 20, 2016.
6. World Bank. Poverty headcount ratio at national poverty lines (% of population). World Bank Data. http://data.worldbank.org/indicator/SI.POV.NAHC?locations=HN. Accessed October 20, 2016.
7. Rural Poverty Portal. Rural poverty in Honduras. Rural Poverty Portal. http://www.ruralpovertyportal.org/country/home/tags/honduras. Published 2014. Accessed October 20, 2016.
8. Ponce C. Elimination of the vectorial transmission of Chagas disease in Central American countries: Honduras. *Memórias do Instituto Oswaldo Cruz*. 1999;94(1):417-418.
9. Abad-Franch F, Valença-Barbosa C, Sarquis O, Lima MM. All that glisters is not gold: Sampling-process uncertainty in disease-vector surveys with false-negative and false-positive detections. *PLOS Negl Trop Dis*. 2014;8(9):e3187. doi:10.1371/journal.pntd.0003187.
10. Hashimoto K, Álvarez H, Nakagawa J, et al. Vector control intervention towards interruption of transmission of Chagas disease by Rhodnius prolixus, main vector in Guatemala. *Memórias do Instituto Oswaldo Cruz*. 2012;107(7):877-887. doi:10.1590/S0074-02762012000700007.
11. Japan Internal Cooperation Agency. Japan International Cooperation Agency—Japan's ODA Ambassador. 2011. https://www.jica.go.jp/english/ir/financial/pdf/articles_120405.pdf. Accessed October 20, 2016.
12. Takaoka H, Suzuki T. Epidemiology and control of Guatemalan onchocerciasis. *Trop Med Health*. 2015;43(Suppl):87-94. doi:10.2149/tmh.2015-S13.
13. World Health Organization. *Control of Chagas Disease: Second Report of the WHO Expert Committee*. Geneva: World Health Organization; 2002. http://apps.who.int/iris/bitstream/10665/42443/1/WHO_TRS_905.pdf. Accessed April 20, 2017.
14. Organización Panamericana de la Salud, WHO Department of Control of Neglected Tropical Diseases, WHO Innovative and Intensified Disease Management. *Estimación Cuantitativa de La Enfermedad de Chagas En Las Américas*. Montevideo: Pan American Health Organization; 2006. http://ops-uruguay.bvsalud.org/pdf/chagas19.pdf. Accessed April 20, 2017.
15. World Health Organization. Chagas disease in Latin America: an epidemiological update based on 2010 estimates. *World Health Organization Weekly Epidemiological Record*. 2015;90(6):33-44.