PRESIDENT'S MALARIA INITIATIVE

Peru Vector Control Needs Assessment Report

Integrated Vector Management (IVM) Task Order 2

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EXECUTIVE SUMMARY

The vector control needs assessment (VCNA) was conducted in Peru from June 26 to July 6, 2012. The objectives of the VCNA were to:

i. Clarify capacities, gaps and constraints to vector control, particularly entomological surveillance and monitoring

ii. Identify and prioritize intervention options and deployment strategies

iii. Establish or improve the appropriate management and operational systems for sustainable implementation of vector control interventions

iv. Provide a basis for the evaluation of vector control interventions

v. Provide realistic and cost-effective options to address the constraints

Peru decentralized vector control in 2008, and regions are performing vector surveillance and control with assistance from regional reference laboratories which are supported by the National Institute of Health. Even though there is a strong infrastructure for vector control, the frequent outbreaks of malaria and dengue detract from time and resources available for vector control, monitoring, and surveillance. Due to a lack of standardized training in vector control techniques and monitoring and surveillance methodologies, little is known about the quality and effectiveness of on-going vector control methods.

However, through increased collaboration and coordination with the central level, and with guidance from nearby countries such as Colombia, Peru stands to greatly increase the quality of its current vector control operations. Lessons learned from key activities, such as intermittent irrigation of rice fields for malaria vector control, should be widely disseminated for greater application both throughout the country and the region.

1.0 INTRODUCTION

Peru is part of the Amazon Malaria Initiative (AMI), which is a 12-country regional program that began in 2001 with the objective that *"Malaria control programs in the Amazon Basin sub-region substantially incorporate selected best practices."* AMI vector control partners (U.S. Centers for Disease Control and Prevention, Pan-American Health Organization, and RTI International) are working to improve vector control and entomological monitoring in the region of the Americas by performing vector control needs assessments (VCNAs) to review existing vector control and entomological monitoring and surveillance strategies and operations and identify challenges and opportunities to improve current efforts. More specifically, the VCNA process:

a. Assisted each country in reviewing opportunities and needs for implementing the AMI Strategic Orientation Document (SOD) for vector surveillance and control in the Americas and identifying viable options for addressing them. Particular emphasis was placed upon needs to achieve the short-term objectives of the AMI vector control partners joint work plan.
b. Enabled the integration of the discrete, on-going activities of AMI partners into the broader context of national and AMI priorities.
c. Provided a sound basis for developing specific activities to be included in the joint work plan, based on country needs.

Based on the VCNA, specific national plans of action will be developed and countries will be supported, as much as possible, to implement the plans during the subsequent years.

The majority of malaria cases in Peru occur in the regions of Loreto and Tumbes (Figure 1), and each region poses a unique set of challenges. In Tumbes, Anopheles mosquitoes are resistant to all pesticides used for public health, making insecticide-based interventions ineffective. The sheer size of Loreto, the largest region in Peru, demands a network of vector control personnel stationed throughout the region, and the only way to access many remote areas is by boat or plane.

Vector control is decentralized, and the regions make their own decisions and plan activities for vector control and entomological monitoring and surveillance. There has been a recent upsurge in dengue cases and numerous outbreaks which have sickened large numbers of people. The Ministry of Health developed the document "Technical Health Standards for the Implementation of *Aedes aegypti* Surveillance and Control" which provides guidelines and scenarios for dengue vector control and surveillance. No such document exists for malaria vector control and surveillance. Environmental health workers perform vector control for both malaria and dengue, but given the strong regional interest in dengue control, the majority of their time is spent on dengue vector control and surveillance.

Therefore it is necessary to review on-going vector control and monitoring/surveillance operations for both malaria and dengue to identify opportunities to strengthen vector control, particularly for malaria, using already-available resources and strategies in place.

Map of Peru

Figure 1: Information was collected at the regional offices in Iquitos, in the region of Loreto (Point 1) and in Tumbes, in the region of Tumbes (Point 2), and at the *Instituto Nacional de Salud* (National Institute of Health, or INS) and at the Environmental Health Department (DIGESA) in Lima (Point 3).

2.0 SITUATIONAL ANALYSIS

This section presents the status of the priority areas of assessment. Existing constraints are reviewed. Opportunities for addressing the identified constraints or further improving vector management are then discussed in Section 3.

2.1 STRUCTURE, RESOURCES AND FUNCTIONS

2.1.1 STRUCTURE

Malaria control in Peru is divided between two departments within the *Ministerio de Salud* (MINSA, or Ministry of Health). The *Dirección General de Salud Ambiental* (DIGESA, or the Environmental Health Department) oversees vector control for all vector-borne diseases in Peru, and the *Dirección General de Salud de las Personas* (Department of Human Health) is responsible for malaria diagnostics and treatment. The "Area de Vigilancia y Control de Vectores, Roedores, y Ordenamiento del Medio" (Section for Monitoring and Control of Vectors and Rodents and Environmental Management), which is situated within the *Dirección de Saneamiento Basico* (Basic Sanitation Directorate) in DIGESA is

Structural Organigram of the Ministry of Health

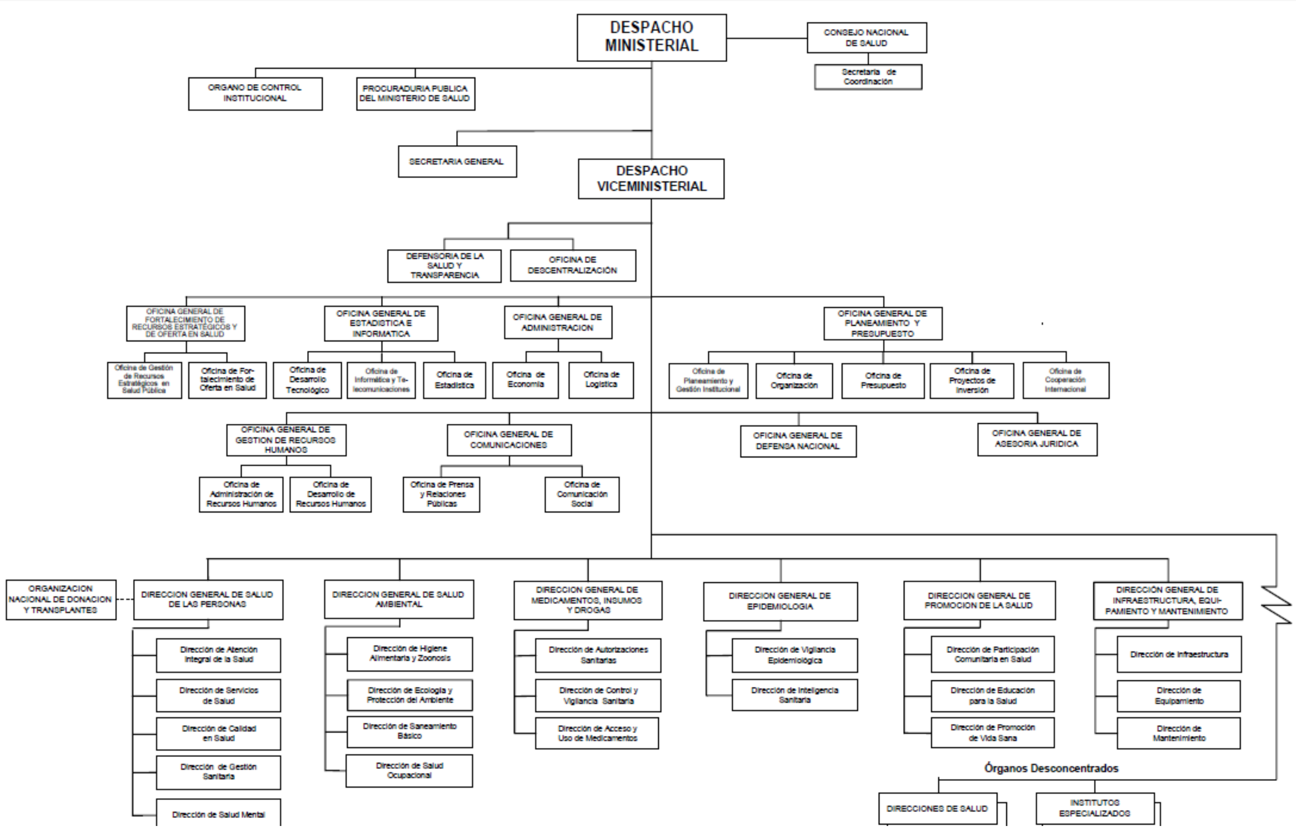

Figure 2: This figure shows the structure of the Ministry of Health (MINSA).

responsible for overseeing vector control of all vector borne diseases. The vector control unit at DIGESA is comprised of six biologists, one veterinarian, two technicians and one secretary. The MINSA organizational structure is presented in Figure 2.

MINSA's objective for vector-borne diseases is to "decrease and control infectious diseases, with emphasis on poor and very poor populations." There is not a national strategic plan for vector control; however this was included in DIGESA's national operation plan before decentralization. Following decentralization, operational plans for vector control are currently developed at the regional level. DIGESA develops a monthly schedule for travel to regions for supervisory visits, or when technical assistance is requested.

The regions (refer to map in the Introduction) maintain the same organizational structure as MINSA, and the regional vector control program in Tumbes is called *Estrategia Sanitaria Regional de Enfermedades Metaxenicas y Otras Transmitidas por Vectores* (National Health Strategy for Tropical Diseases and Other Vector-Borne Diseases).

In Loreto, malaria, dengue and leishmaniasis control is done by the *Direccion Regional de Salud Ambiental* (Regional Environmental Health Department, or DIRESA) within the *Centro de Prevencion y Control de Enfermedades* (Disease Prevention and Control Center). The Environmental Health Section (DISA) manages vector control, while the regional reference laboratory is responsible for entomology and laboratory assays.

At all levels of the government (national, regional, and local), vector control personnel are responsible for all vector-borne diseases (VBDs), including malaria, dengue, leishmaniasis, bartonellosis, and others, depending on which VBDs are prevalent. At the local level, environmental health workers are responsible for VBDs, adequate management of foods and water, and zoonotic diseases. They are involved in vaccination campaigns, mosquito collections, larvicide operations, spray operations, and other activities decided upon at the local level. Environmental health workers are not responsible for performing insecticide efficacy tests on walls or treated nets, identifying mosquitoes, or performing insecticide susceptibility tests.

2.1.1a History of Vector Control Program

The National Malaria Eradication Program was created in 1957. This was a vertical program with two sections: Epidemiology (including diagnosis and treatment, parasitology and entomology labs) and Field Operations (including entomological surveillance and vector control). IRS with DDT was the main control strategy used. The eradication program transferred to *Dirección General de Salud Pública* (General Public Health Department) in 1969. In 1973, the malaria eradication program became part of the *Dirección Especial de Control de Enfermedades Transmisibles* (Special Directorate of Communicable Disease Control), and was no longer autonomous. It continued as a vertical program; however the budget depended on the central level. The program began to encounter difficulties in direct contracts, insecticide and antimalarial drug procurements, and field activities. In 1980, human resources and equipment began to be transferred to the health facilities in the regions. The eradication campaign ended and the malaria control program became part of the *Dirección General de Salud de las Personas* (Department of Human Health).

DDT was banned from Peru in 1991, and the *Estrategia Sanitaria Nacional para Malaria y Otras Enfermedades Transmitidas por Vectores* (National Health Strategy for Malaria and Other Vector-Borne Diseases) was created within the Department of Human Health. In 2006, the national malaria control program was abolished and vector control functions for all vector-borne diseases were transferred to DIGESA (previously, DIGESA had only been responsible for vector surveillance), while the Department of Human Health was made responsible for treatment and diagnostics of vector-borne diseases. In 2008, the budget for vector control was decentralized and funds were now sent directly to the regional governments by the Ministry of Finance.

2.1.1b Decentralization

Some of the constraints associated with decentralization include:

- Political pressure and local perceptions of disease risk can influence vector control
- Lack of information exchange and communication between central and regional levels

The primary advantage of decentralization is that the decision-making bodies and resources are located within the regions, rather than at the sometimes-distant national level. Those who are closest to the problems decide what needs to be done. However, this also poses a unique set of challenges. In some cases, political pressure at the local level influences vector control. For example, almost all vector control resources in the region of Tumbes go towards *Aedes aegypti* control because dengue is perceived to be a bigger problem than malaria. In the case of outbreaks, petroleum businesses and other local companies will donate equipment and pesticides to areas of outbreaks without prior consultation; this results in an influx of insecticides or equipment that may not be well-suited to the region. For example, the region of Loreto regularly receives donations of wettable powder insecticides, but the high levels of humidity in the area make wettable powder very difficult to use.

Also, the national level is not always well-informed of activities being performed in the regions. The regions often make decisions, program activities, and develop schedules without informing DIGESA, which remains unaware of what is happing in the regions. There is confusion at the national level over NAMRU's relationship with the region of Loreto (ref: Section 2.1.7b). In general, DIGESA is unclear about the informal relationship between NAMRU and DISA, and also of assistance provided by NAMRU in the control of malaria and dengue outbreaks.

2.1.2 INFORMATION FLOW

Information flows from the localities and regions up to DIGESA and related entomological data flows from regional reference labs to INS. The information received by INS is shared with DIGESA to help inform decision-making. Information such as number of disease cases is sent on a weekly basis, while other information, including entomological indicators (human landing catches, larval densities), are sent monthly. Results from insecticide susceptibility tests performed at the regional level are sent to INS, which then verifies the information with additional tests if necessary. When INS travels to a region to perform additional tests, they leave a copy of the report of their results at the regional level to assist in local decision-making.

In Tumbes, no malaria vector surveillance activities are conducted, and no indicators are reported. On a weekly basis, Tumbes sends reports of number of houses sprayed, larviciding activities, etc. for dengue control. At the local hospital Jamo in Tumbes, the hospital epidemiologist communicates weekly the number of cases of malaria and dengue to DIRESA. When immediate assistance is needed, such as when an outbreak is detected, the hospital communicates directly with DIGESA.

2.1.3 HUMAN RESOURCES

Some of the human resource constraints for vector control include the following:

- Lack of standardized training or refresher courses provided to environmental health workers, spray operators, new hires, and other people involved in vector control and/or entomological monitoring

- Environmental health workers are burdened with a surplus of activities and responsibilities, and do not have adequate time for malaria vector control and entomological monitoring and surveillance

- Lack of certification for environmental health workers; by providing certification, it may be possible to avoid high job turnover of already-trained health workers with each change of administration

Human resource capacity and availability varies greatly from region to region. Public health is not a priority in universities, and there is not a wide range of medical entomology courses at universities in Peru. Therefore many of the entomology technicians throughout the regions are trained in the field or on the job. Each region has a biologist, but not necessarily an entomologist.

In 1998 DIGESA decided to form a network of biological entomologists. There was a series of 15-day trainings led by PAHO in various sites which trained a total of 90 entomologists throughout the country. Of the original 90, there now remain only three trained entomologists in Loreto. Generally, the regional levels are responsible for organizing trainings and requesting assistance from the national level. Currently, INS conducts entomology trainings in Lima each year for people from 12-14 regions on topics such as taxonomy and insecticide susceptibility testing. At the regional level, environmental health workers are trained by their superiors and receive little/no formal training. DIGESA and INS are the primary entities that provide capacity building throughout Peru. They frequently work together to provide trainings to environmental health workers. In some cases, the existing environmental health workers will also train in-coming local technicians.

Depending on the region, environmental health workers have a wide range of responsibilities, as discussed in Section 2.1.1. This may mean that they are unable to dedicate enough of their time to VBD control. In Tumbes, the environmental health workers perform spray operations, larviciding and provide community education. These activities are conducted from the regional level rather than the local level due to a lack of desire to live in remote communities. Tumbes has 40 environmental health workers, but 11 are budgeted to work outside of the region of Tumbes, meaning that only 29 environmental health workers are available for vector control operations in an area covering 155,00 people. The Tumbes environmental health workers are divided into four teams, of which three teams perform daily vector control activities or other environmental health activities in the region, while the other team stays in the city of Tumbes, preparing larvicide or carrying out local vector control operations. Tumbes has recently begun implementing a project called "*Fortalecimiento de la estrategia de gestion integrada de prevencion y control de malaria y dengue en la region de Tumbes*" (Strengthening the integrated management strategy for prevention and control of malaria and dengue in the region of Tumbes) to improve regional field activities for malaria and dengue control. It is a 4.3 million soles ($1.5 million) project and 96 people were certified after a one-week training to identify mosquitoes and perform control activities in June 2010. The 96 workers trained included technicians, nurses, and others, all of whom will work on the project for one year and are paid monthly.

In Loreto, each province has a biologist who is responsible for vector control and surveillance (for malaria they only do control; for dengue they do control and surveillance). Within each province, at least five local technicians, paid by DIRESA and trained by the biologist, assist with vector control activities, including IRS. In Iquitos, the local vector control unit is made up of four networks, each of which has biologists that perform vector control. Each health center in Loreto has a health promoter that works with surrounding villages to do thick smears for malaria diagnosis and treatment. The promoters are volunteers chosen by the communities.

The network of entomologists in the regional reference laboratories is trained yearly by INS and DIGESA. DIGESA would like to provide certification to local environmental health workers stating that they have been trained in basic field entomology, similar to certifications provided by *Servicio Nacional de Aprendizaje* (National Learning Service, or SENA) in Colombia. SENA provides trainings following nationally recognized standards, after which participants receive certification. By following this process, DIGESA hopes to avoid high job turnover. DIGESA has approached AMI/RAVREDA with this suggestion, but it has not been finalized for budgetary reasons.

2.1.3a Human Resource Challenges

The predominant challenges to human resources for vector control and entomological surveillance are:

- Departure of trained vector control professionals to countries with higher salary potential
- Lack of experienced regional vector control workers familiar with local dynamics
- Lack of vector control workers in peripheral areas in Tumbes

There are a number of human resource challenges for vector control in all regions and levels in Peru. Frequently, trained biologists and entomologists leave Peru to work in other countries, such as Brazil, where they have the ability to earn higher wages. Oftentimes, personnel will receive training and then leave, as there are no policies or incentives to keep trained personnel. The program *Servicio Rural Urbano Marginal en Salud* (Marginal Urban Rural Health Service or SERUMS) sends professionals to rural regions for community service, where they are trained for one year in control and prevention of local diseases and other topics. However, following their one-year tenure the SERUMS trainees depart, leaving the areas once again without knowledgeable, trained human resources. This produces a number of challenges, one of which being conflicts with rural populations. Conflicts sometimes erupt between local communities and regional service providers because staff from the regional level do not often remain employed in the regions for long enough to learn the idiosyncrasies of the local levels, and then once they are knowledgeable they leave. This is further compounded by poor communication between regional and local levels.

In Tumbes, all environmental health workers are located at the regional level because they do not want to live in small rural communities. Also, a new hospital in Tumbes is being built and the region is trying to attract medical doctors and trained personnel by offering them higher-than-normal salaries, but they do notwant to work in the rural northern areas.

2.1.4 NATIONAL INSTITUTE OF HEALTH

The following opportunities with the National Institute of Health were identified:

- Presence of regional reference laboratories with insectaries and ability to conduct insecticide susceptibility tests
- Well-developed taxonomy laboratory
- Working relationship with DIGESA and DIRESA
- Presence of susceptible *An. albimanus* strain "Sanarate"

The *Instituto Nacional de Salud* (INS, or National Institute of Health), based in Lima, oversees a network of regional reference laboratories and works together with DIGESA to monitor local mosquito populations. The INS taxonomy laboratory reference collections date back to the 1950s. Regions send local mosquito species, both anophelines and culicines, which they are unable to identify to the taxonomy lab at INS. The frequency of identification requests varies by region: some send mosquito specimens every three months, while others will send mosquitoes only once a year.

The insectary at INS contains *Anopheles albimanus* and *Aedes aegypti*; *An. darlingi* are extremely difficult to cultivate in an insectary setting and are therefore not present. A susceptible strain of *An. albiumanus* ("Sanarate") is kept in the insectary and is used for comparison with field-caught mosquitoes. Colonies of triatomines and fleas are also kept in the insectary.

INS does not perform PCR or ELISA for determination of *Plasmodium* natural infection in mosquitoes, but they have a plate reader that is used for biochemical microplate assays to detect mechanisms of insecticide resistance. INS conducts both CDC and WHO insecticide susceptibility tests, while the regional labs only perform bottle assays. Insecticide-impregnated papers are purchased from Malaysia for the WHO tests. They also impregnate their own papers following WHO guidelines.

Regional reference laboratories throughout the country perform insecticide susceptibility tests. In 1999 there was a training course for insecticide susceptibility testing. In 2011 the regional reference lab in Tumbes was able to start conducting susceptibility tests; before this date staff from INS would travel to the region each year to conduct susceptibility tests on the local vector species. There is not a regular schedule for susceptibility tests at the regional level because they are only able to conduct the tests when they receive diagnostic doses from the national level.

There are insectary laboratories or regional reference laboratories in 75% of the regions. In the 25% that do not have laboratories, there are not vector-borne diseases and therefore no need for the laboratories. At the local level, there are microscopes, IRS equipment, and transportation resources.

A study conducted in Iquitos by Zamora-Perea *et al*. in 2009 showed that the bottle assay and the WHO tube test are able to differentiate mosquitoes that are resistant or susceptible to deltamethrin eqally. Insecticide susceptibility tests have been performed in Loreto for a number of years, initially at DISA and currently at the regional reference laboratory. WHO tests and CDC bottle tests are used for susceptibility testing in *Anopheles spp.*, and no resistance had been found. The laboratory has performed tests with deltamethrin, lambdacyhalothrin, alphacypermethrin and bendiocarb. Laboratory biologists perform quality control on mosquitoes identified by biologists in the field and collect mosquitoes in order to perform susceptibility tests. The regional reference laboratory has cones and they perform insecticide residuality tests, but only for private insecticide companies and as part of scientific collaborations with academic institutions and NAMRU-6, and not for operational purposes.

The INS has a *Centro de Investigacion de Enfermedades Tropicales* (Tropical Disease Research Center) that focuses primarily on investigations in Iquitos. It was constructed with support from USAID, and does research on bacteria, viruses, parasites and fungus rather than operational investigations. The research center houses an insectary and has equipment necessary to carry out entomological surveillance and monitoring; however, there is currently no entomologist employed to lead the activities.

2.1.5 FINANCING

The following challenges in vector control funding were identified:

- Predicated on funding coming in from central level to the regions

- Funding amount based on what was spent in previous years
- *Presupuesto por Resultados* (Budgeting for Results) dictates that regions must show that they used funds provided for budgeted activities. However, this is also an opportunity as it allows regions to showcase their accomplishments. In the case of Loreto, this has resulted in increased funding
- Not eligible for Global Fund projects

Nearly all vector control activities in Peru are financed by the government. The Ministry of Economy and Finances sends the regional budgets to DIGESA for their input, but the funds are sent directly to the regions. Budgets are developed based off of amounts spent in previous years. After decentralization, the ministries lost control over how regions were spending funds for intended purposes. For example, instead of paying a regional biologist/entomologist responsible for overseeing vector control, the regions could opt to hire new nurses. In order to combat this challenge, in 2011 the Ministry of Finance developed a budgeting planning process called *Presupesto por Resultados* (Budgeting for Results, or PPR), in which regions have to show that they used the money for the intended purpose or they get less money the following year. Generally the budgeted funds are insufficient for regional needs, including human resources. Budgets are developed based on items needed, person hours, materials, local transport, etc. At the national level, DIGESA is unable to quantify the number of households covered by vector control interventions because regional budgets only specify items needed rather than households to be covered.

In the case of Loreto, PPR has facilitated an increase in the amount of funds provided for vector control. Before PPR, DISA performed vector control operations that were not included in the budget. Now, when they show that they are able to complete more activities than originally planned, they obtain increased funding.

Peru also receives funds annually from AMI/RAVREDA in an amount of approximately $200,000 per year. These funds are used for resistance monitoring for anti-malarial drugs and quality assurance, improving malaria diagnostics, and vector control. Originally AMI/RAVREDA funds were programmed to be used in the North and the Amazon region, but now funds are used solely in the Amazon. Sometimes the funds do not arrive on-time, which makes programming and planning difficult.

Extreme flooding early in 2012 in Loreto has exhausted regional resources. The region spent extra money went to pay for emergency vector control in peripheral areas, as the national emergency fund established is only for Iquitos. Now the region has no funds remaining to pay per diems for field work or supervision, which make vector control activities difficult.

Peru is not eligible for Global Fund financing, as it is considered too developed.

2.1.6 OPERATIONAL RESEARCH

This section covers operational research that is immediately relevant to vector control:

- Demonstration that intermittent irrigation of rice fields can control larval densities in rice fields in the North
- Experimental huts with evaluations of LLINs

2.1.6a Experimental Huts

Research using experimental huts was performed and funded by AMI/RAVREDA in Zungarococha, Iquitos from May 18-July 18, 2008 to evaluate the effect of LLINs on the behavior of *An. darlingi*. The study found that Olyset nets reduce the proportion of female mosquitoes that enter the huts. Final results have not yet been published.

2.1.6b Intermittent Irrigation of Rice Fields

Along the North Coast of Peru, where malaria is endemic and mosquitoes are resistant to insecticide, flooded rice fields provide ideal mosquito breeding habitats. These crops have been subjected to a diverse array of insecticides, and because of this pressure, the main malaria vector *An. albimanus* is now showing high levels of resistance to all insecticides approved for public health use: organophosphates, organochlorides, carbamates and pyrethroids. The land is flooded to allow the rice to grow, and two or three crops are harvested each year. This flooded land provides an ideal larval habitat for *An. albimanus*, which generates a rise in *An. albimanus* populations, and subsequently in malaria transmission.

In 2005 MINSA formed an intersectoral committee led by the Regional Government of Lambayeque that included the Ministries of Health and Agriculture and regional and international agencies with the purpose of preventing malaria in the northern Peruvian coast in areas where rice is cultivated. This was accomplished by modifying the irrigation system so that the fields dry for a period of 8 days during the growing cycle, which does not harm the crops, causing a decrease in mosquito larvae by 87% and also reducing the irrigation costs. This research in the Lambayeque region is funded by the International Development Research Center in Canada; it has not been implemented with wide success in other regions, such as Tumbes, because the rice cultivators are hesitant to change their farming practices. In September 2010 MINSA signed a resolution supporting the use of intermittent irrigation of rice field technique for all rice fields in Peru in order to reduce malaria.

2.1.7 RESEARCH INSTITUTIONS

2.1.7a International Centers of Excellence for Malaria Research

Perú is participating two International Centers of Excellence for Malaria Research (ICEMR) funded by the U.S. National Institutes of Health. Cayetano Heredia University is collaborating with both of the centers: the Peruvian/Brazilian Amazon Center of Excellence in Malaria and the Latin American Center for Malaria Research and Control. The goal of the Latin American Center for Malaria Research and Control, based in Colombia, is to establish the "Centro Latino Americano de Investigacion en Malaria," or CLAIM. This ICEMR focuses on malaria epidemiology, transmission and pathogenesis. The aim of the Peruvian/Brazilian Amazon Center of Excellence in Malaria is to develop a comprehensive approach to understanding the biological features of malaria in the Amazon region. This will be done by focusing on malaria epidemiology, vector biology and ecology, transmission biology, diagnostics, and clinical pathogenesis. DIGESA or the Minister of Health knows little about the ICEMRs.

2.1.7b Naval Medical Research Unit-6

The following opportunities are available for DIGESA/DIRESA to collaborate with NAMRU-6:

- NAMRU-6 could assist in cultivation attempts of *An. darlingi* mosquitoes
- NAMRU-6 tests novel vector control interventions that may be appropriate for special/mobile populations
- NAMRU-6 assists in procuring expensive or difficult-to-procure equipment such as motorized hand aspirators

The Naval Medical Research Unit N° 6 (NAMRU-6), located in both Lima and Iquitos, Peru, was established in 1983 through an agreement between the Surgeon Generals of the Peruvian and U.S. Navies, with the concurrence of the U.S. Department of State and the Peruvian Ministry of Foreign Affairs. The agreement established a cooperative medical research program in Peru to study infectious diseases of mutual interest, the goal of which is to improve the operational readiness of the U.S. forces and to enhance the public health of the Peruvian people. NAMRU-6 has an active entomology research program that studies arthropod vectors of disease, including mosquitoes, and possible methods to improve their control.

NAMRU-6 focuses primarily on operational research, and has to obtain approval from DIRESA before entering communities for research purposes. They are currently implementing a study on BombaMax, a fogging intervention used for dengue control with the insecticide pyriproxyfen. NAMRU-6 also completed a study with the Liverpool School of Tropical Medicine on curtains impregnated with deltamethrin for dengue control. The results have not yet been published.

In the event of VBD emergencies, DISA contacts NAMRU-6 and NAMRU-6 will lend equipment such as microscopes or trucks. NAMRU-6 also has an established surveillance system in Loreto with 10 health centers in high-risk malarial areas, where fever cases are detected within neighborhood cohorts. NAMRU-6 immediately shares confirmed malaria cases with local authorities, and provides monthly statistical reports of all cases in the region to DISA.

The NAMRU-6 insectary has cultivated *An. darlingi* up to the F2 generation, but has not managed to establish *An. darlingi* colonies in the insectary.

2.2 MAJOR VECTOR-BORNE DISEASES

The following table provides a summary of vector-borne diseases present throughout Peru, primary vectors, and potential vector control interventions.

Prevalent vector-borne diseases	Primary vector(s)	Potential vector control interventions
Malaria	*Anopheles darlingi*, *An. albimanus*, *An. benarrochi*	Indoor residual spraying (IRS), long-lasting insecticidal nets, larval source management
Dengue	*Aedes aegypti*	Fogging, larval source management
Bartonellosis	*Lutzomyia verrucarum*	IRS, personal protection
Leishmaniasis	*Lutzomyia peruensis*, *Lu. verrucarum and Lu. ayacuchensis*, *Lu tejadei* and *Lu. pescei*	IRS, personal protection
Chagas' Disease	*Triatoma infestans*	IRS

2.2.1 Malaria

Malaria transmission in Peru is typically characterized as unstable, and the majority of the cases are caused by *Plasmodium vivax* (Figure 3). Malaria was almost eliminated in Peru during the global eradication campaign in the 1960s and 70s. However, the number of cases began to increase slowly throughout the late 1970's and the 80's, only to increase in the early 1990's when the use of DDT was prohibited, as shown in Figure 4. In 1994 16,322 cases were reported during an epidemic in Loreto, 49.6% of the cases caused by *P. vivax* and 50.4% caused by *P. falciparum*. During another epidemic in 1997, 121,224 cases were reported (55.2% *P. vivax*, 44.8% *P. falciparum*). In recent years, generally across the country, case numbers have stabilized and nationally the focus has now shifted to dengue, of which there are more outbreaks and cases.

In the region of Tumbes, in the north of Peru along the Pacific Ocean bordering Ecuador, there is permanent year-round malaria transmission due to the proximity of local communities to rice fields and irrigation canals. In 2011, 257 cases of malaria (133 cases of *P. vivax*, 124 *P. falciparum* cases) were reported to the main hospital JAMO in Tumbes. Prior to October 2010, no *P. falciparum* malaria had been reported in four years in Tumbes. In October 2010, there were 10 confirmed cases in soldiers

Percentage of malaria cases by species in Peru from 1995 - 2011

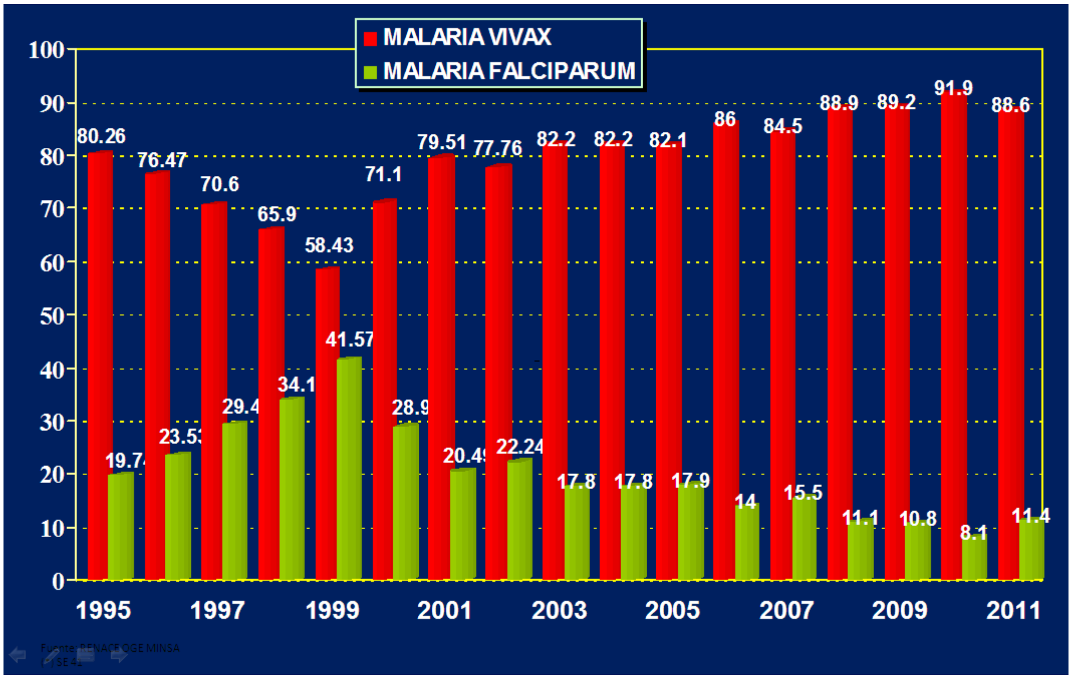

Figure 3: The figure above shows that the majority of malaria cases in Peru are *P. vivax*. From 1995 to 1999 there was a yearly increase in the proportion of *P. falciparum* cases, until 41.57% of cases were *P. falciparum in* 1999 and only 58.43% were *P. vivax*. The proportion has since stabilized, and currently .approximately 88% of cases are *P. vivax*.

in the region of Tumbes returning from Iquitos. In the malaria outbreak following the detection of these cases, the majority of cases were found in the neighborhoods of San Jose and El Milagro. When cases of malaria are found, local medical technicians do active case detection for four weeks, or until no more cases are found. In the case of the 2011 *P. falciparum* outbreak it was difficult to find the reported cases, as many of them provided false addresses. As of July 1, 2012 there have been 20 cases of reported *P. falciparum* in 2012, and no cases within the past ten weeks (from mid-May through the beginning of July).

Reported illnesses in Loreto from 2000-2012 (through week 26)

ENFERMEDADES	AÑOS												
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012*
Fiebre Amarilla Selvática		21	12		1	2	7	2	4	1		1	
Dengue	445	462	5634	865	3035	1979	2078	1812	7586	4371	1349	21196	3310
Malaria	25522	35743	66443	46733	42976	54495	45626	37164	25896	26287	11473	11765	11451
Leishmaniasis	464	440	852	408	293	265	423	284	269	323	314	388	148
Enfermedad de Chagas							1	6	1	3	1	1	1

Fuente: Base NOTI_SP de la Dirección de Epidemiología - DIRESA Loreto

* Hasta la S.E 26

Table 1: The table above shows the number reported cases of yellow fever, dengue, malaria, leishmaniasis, and Chagas' Disease in the Loreto region. Yellow fever cases have decreased to approximately one case per year, while dengue cases have fluctuated each year, ranging from only 865 cases in 2003 to 21,196 cases in 2011. Malaria cases have fluctuated as well, with a general trend towards a decrease in number of cases, although the number of cases for 2012 is close to that of 2011, and case numbers are only available through the middle of the year. Leishmaniasis case numbers are unstable, however the number of Chagas cases has decreased and leveled out at approximately one case per year..

Historical Malaria Curve in Peru from 1939 - 2011

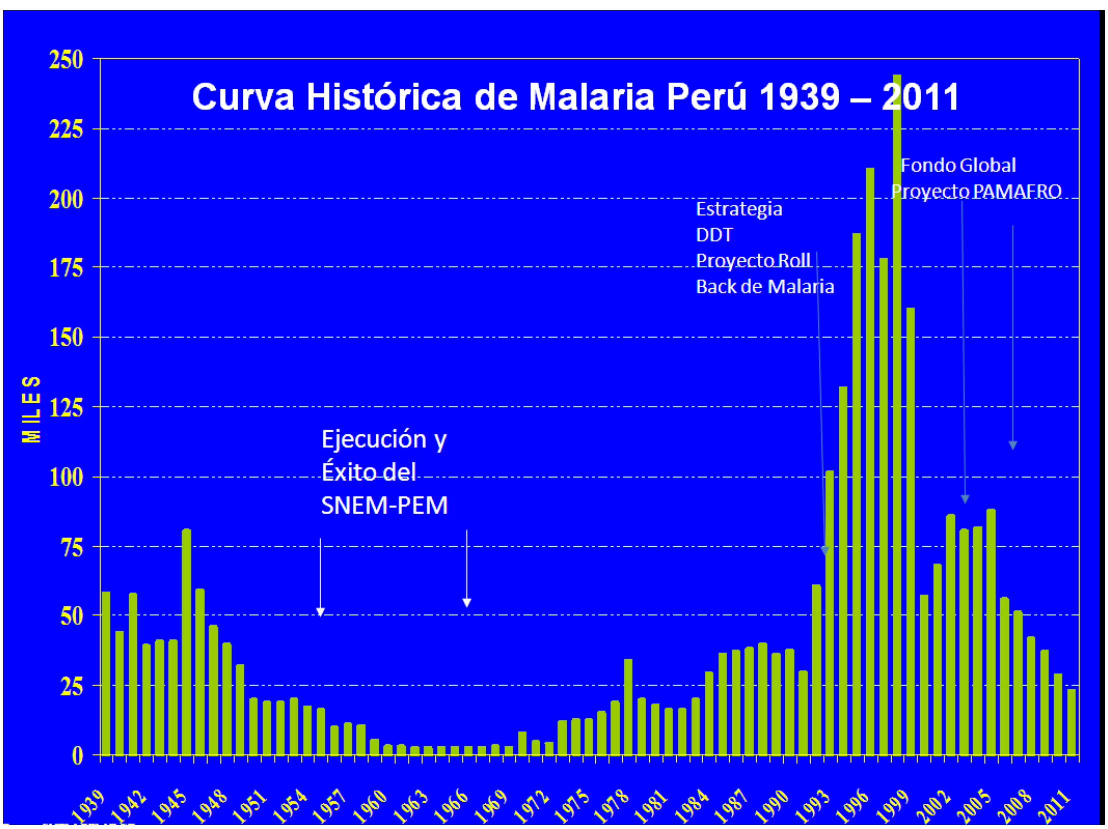

Figure 4: The table above shows the number of malaria cases from 1939 to 2011. The Peru Malaria Eradication campaign was implemented from 1956-1966. The use of DDT was prohibited by the WHO in 1991. In 1994 the *Estrategia DDT* (Timely treatment strategy) and Roll Back Malaria project were implemented. The Global Fund Project PAMAFRO was implemented from 2005-2010.

Severe flooding earlier in 2012 has lead to an increase in the number of cases of malaria in the region of Loreto. As shown in Table 1, the number of malaria cases in Loreto through the middle of 2012 is almost equal to the number of cases reported in 2010 and those reported in 2012. The flood waters reached never-before-seen levels and developed new temporary and/or permanent breeding sites for *An. darlingi* and *An. benarrochi*. The new influx of *An. benarrochi* has displaced other vectors, and the impact of this remains to be seen.

2.2.2 Dengue

Dengue is a large public health problem in Peru, with frequent outbreaks, and receives the highest level of priority at both the national and regional levels.

In 1944 the first studies about mosquitos in Perú started, and in 1958 Perú was declared free of *A.aegypti*, after a national eradication program. In 1984 *A. aegypti* was reported again in Perú in the department of Loreto and, currently, dengue is endemic in 18 out of 25 departments. After an outbreak in 2001, in which 25,500 cases were reported, an average of 6000 cases have occurred every year from 2002 – 2007. However, from 2008, the number of cases increased, reaching almost 30,000 cases for 2011 (Figure 5). An outbreak of dengue serotype 2 in Iquitos in January 2011 resulted in 18 fatalities in one and a half months.

DIGESA has developed thorough technical guidelines for dengue control. According to the national guidelines, entomological interventions are planned according to the vector/disease situation in defined scenarios:

a. *Scenario I: with neither vector presence nor cases*. The activities to do in this situation are entomological surveillance every trimester in 10% of houses, and surveillance in critical points. This surveillance is mainly with larvitraps and ovitraps.

b. *Scenario II: with presence of vector but no cases or imported cases*. Monthly entomological surveys are conducted in 10% of the houses in the localities, larval control in 100% of the houses and evaluation after intervention. In houses with imported cases, adult control plus larval intervention activities.

c. *Scenario III: presence of vector and cases*. Both larval and adult control are conducted.

Larval control is based in the application of the organophosphate temephos in the deposits, and adult control is mainly space spraying or fogging with the pyrethroid alpha-cypermethrin.

Historical tendency of dengue in Peru

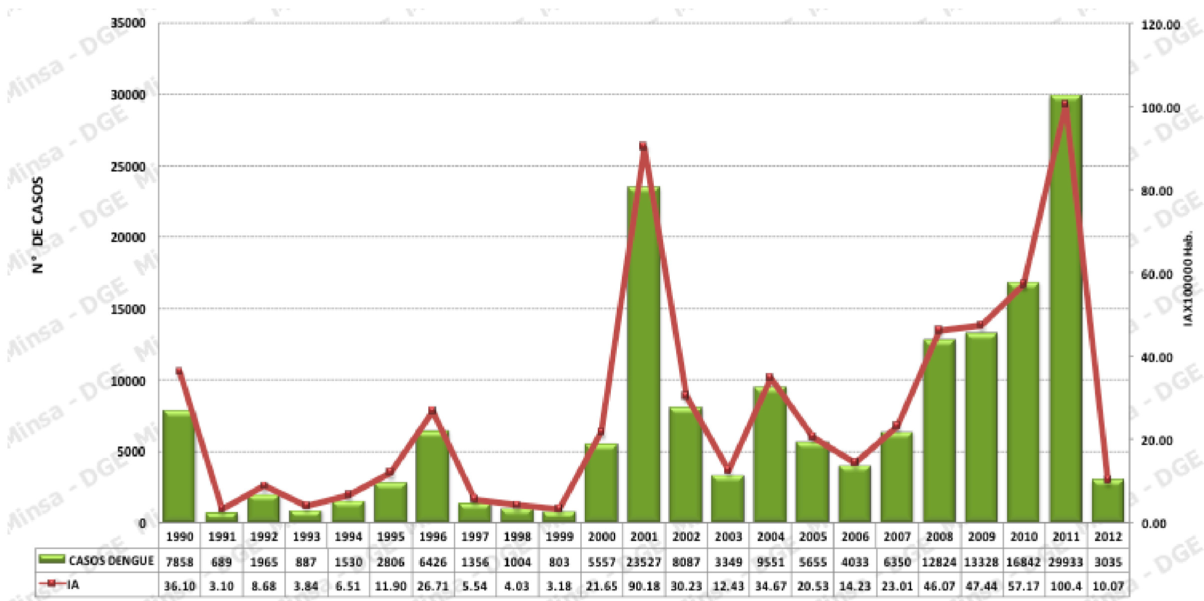

Figure 5: The figure above shows the number reported cases of dengue in Peru on the axis to the left and the annual incidence on the axis to the right from 1990 to the 6th week of 2012. The outbreaks in 2001 and 2011 are clearly visible..

2.2.3 Bartonellosis

Bartonellosis, also known as Peruvian Wart or Carrion's disease, is a vector-transmitted disease caused by *Bartonella bacilliformis*, which is an intracellular bacterial parasite transmitted by sandflies. This disease

Total number of cases of Bartonellosis in Peru by province from 1998-2000

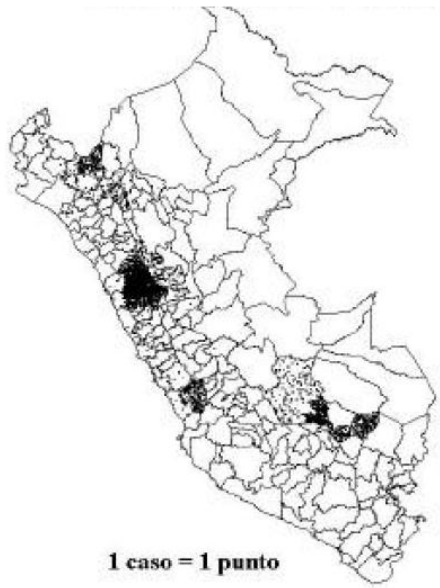

Figure 6 : The figure above shows the total number of cases of Bartonellosis in provinces across Peru from 1998 to 2000. One point is equal to one case, and the dark-colored areas represent those with the highest number of cases. Most of the cases were found in Huanuco, Amazonas, Huancavelica and Cuzco

Total number of Bartonellosis cases in Peru (2002 - 2012, week 19)

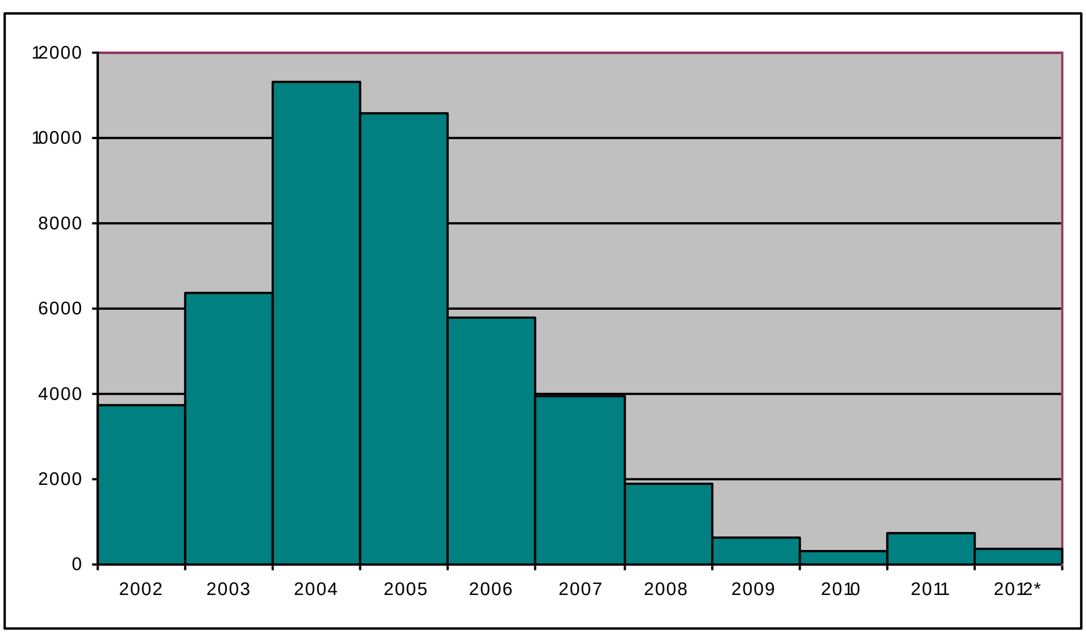

Figure 7: The figure above shows that the number of Bartonellosis cases in Peru peaked in 2004, and has been steadily decreasing since that time.

is uniquely endemic to South America in the inter-Andean areas. Its distribution in Peru is shown in Figure 6. The sandfly *Lutzomyia verrucarum* is the main vector for transmission of the bacteria to humans in the western part of Perú, while in the east is *Lu. maranonensis* and *Lu. robusta*, however other species may be involved in transmission. The female sandfly transmits the pathogen during nocturnal blood feeding on humans. Presumably the insects feed on the blood of an infected individual and spread the pathogen via saliva during a subsequent meal.

Figure 7 shows the number of cases from 2002 to 2011 (and until week 19 of 2012). An outbreak took place in 2004 with around 11200 cases. The number of deaths has followed the epidemic curve, with 61 deaths in 2004 being the highest number of deaths in the last 10 years. This number has been reduced to 29 in 2005, 19 in 2006, and around 10 every year from 2007 until now.

The main disease control strategies are treatment of patients and IRS with pyrethroids. Deltamethrin and lambdacyhalothrin have been used, when outbreaks are detected. Passive and active surveillance of patients is carried out regularly in endemic areas.

2.2.4 Leishmaniasis

Cutaneous and muco-cutaneous leishmaniasis are both prevalent in Perú, with 75-80% of cases reported being cutaneous leishmaniasis. Two species of parasite are predominant: *L. braziliensis peruviana* (responsible for the cutaneous form) and *L. braziliensis braziliensis*, which produce the muco-cutaneous form. Some isolated cases of *L. amazonensis* have also been described. The historical behavior of the incidence showed an increase in the number of cases from 1984 – 1996, with the incidence rising from 12.7 to 40 cases/ 100,000 inhabitants. Since 1999, incidence has been stable at around 40 cases/100,000 people per year. The disease is present in 12 departments, with higher prevalence in the eastern part of the country. In Perú, 131 species of *Lutzomyia* have been reported, but only 5 to 10 species are vectors of leishmaniasis. *Lutzomyia peruensis, Lu. verrucarum and Lu. ayacuchensis, Lu. tejadei* and *Lu. pescei* are considered the main vectors.

Currently zero cases of visceral leishmaniasis are reported; however this does not necessarily mean that there are no cases. Visceral leishmaniasis is present in Bolivia and there is a possibility of case importation.

2.2.5 Chagas Disease

An estimated 650.000 Peruvians are infected with Chagas disease, which is present in both southern and northern Peru (Figure 8). However, because little research has been done in the north of Peru, the region has not developed significant programs to help control the disease. The south-western region of the country is considered the most endemic area for Chagas disease. The age group most affected is between 20 and 54 years.

Endemic areas for Chagas Disease in Peru in 2004

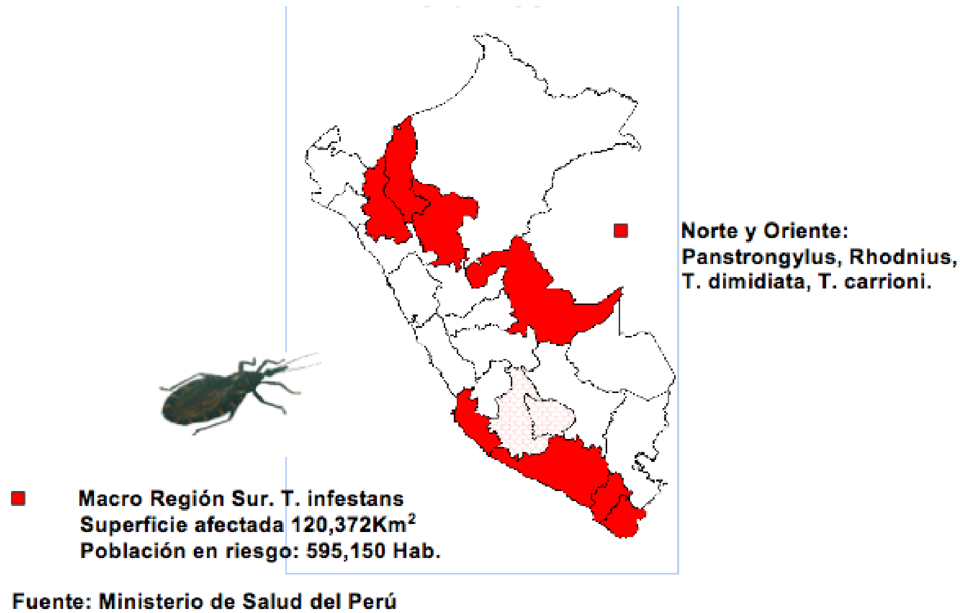

Figure 8 : The figure above shows the areas in Peru endemic for Chagas Disease. In the north Chagas vectors include . *T. carrioni,T. dimidiata, Rhodnius spp.* and *Panstrongylus spp.* and the disease is endemic in Ucayali, San Martin, Amazonas, and Cajamarca. In the south it is endemic in the regions of Tacna, Arequipa, Ica and Moquega, where the primary vector is *T. infestans* and 595,150 people are at risk.

This disease is of obligatory notification, however acute cases are rarely diagnosed and reported. Epidemiological surveillance is based on the systematic surveillance of the presence of the vector and their examination for infection, the presence of reservoirs, serologic examination in blood banks and surveys in the communities in endemic areas.

Seventeen species of triatomines have been registered in the country. *Triatoma infestans* is the most important because of its domestication, and it is considered the main vector of *T. cruzi*. The distribution of this species coincides with the most endemic region for Chagas disease in the south-western part of the country. *Panstrongylus herreri* is the vector responsible for most of the transmission in the north-eastern region. Other species considered vectors and found mainly in the north are *T. carrioni, Rhodnius ecuadoriensis* and *Panstrongylus chinai*.

Entomological surveillance for Chagas disease is carried out throughout periodic surveys to assess the infestation index as well as the infectivity rate. The infestation index is one of the entomological indicators for evaluation of the control measures and also facilitates the establishment of the degree of dispersion of the vector species, as an indicator of potential transmission risk.

Mainly in the south, a vector control program targeting *T. infestans* is trying to eliminate the vector from the houses, using IRS with pyrethroids. Peru was also involved in a WHO program to eliminate vector transmission using IRS within the region. Currently Chagas is no longer transmitted vectorially in region of Tacna.

2.2.6 Yellow Fever

Yellow fever is largely controlled in Peru, due to vaccination campaigns that reach almost 100% of the population. However, it could be transmitted in the forest in areas of informal mining in the south, where not all workers have received the vaccination. *Ae. albopictus* has not yet appeared in Peru, but it is present it in Brazil, with whom Peru shares a porous border with large numbers of people frequently crossing from country to country.

2.3 TOOLS, METHODS, STRATEGIES, AND COVERAGE

In Tumbes no vector control activities are conducted for malaria control because the vector in this region, *Anopheles albimanus*, is resistant to all insecticides; case detection and treatment are the primary methods used to control malaria. As discussed in Section 2.1.3, at the regional level the same person is responsible for all VC interventions and for training field technicians.

2.3.1 INDOOR RESIDUAL SPRAYING

Some of the challenges to indoor residual spray operations in Peru include:

- Inadequate number of spray rounds in Loreto with deltamethrin, which has a residual effectiveness of only three months

- Lack of standardized training for spray operators

Indoor residual spraying (IRS) is the only form of malaria vector control that is implemented regularly in Peru. IRS was the main vector control method used during the National Malaria Eradication Campaign from 1957-1980, during which time the primary insecticide used was DDT. As the Malaria Eradication Campaign ended and resources and funds were shifted to the districts in the late 1970s and 1980s, the number of houses sprayed nationally began to decrease (Figure 9). In Tumbes 6,000 houses were

Number of households sprayed national and number of malaria cases reported by year from 1958 to 1983

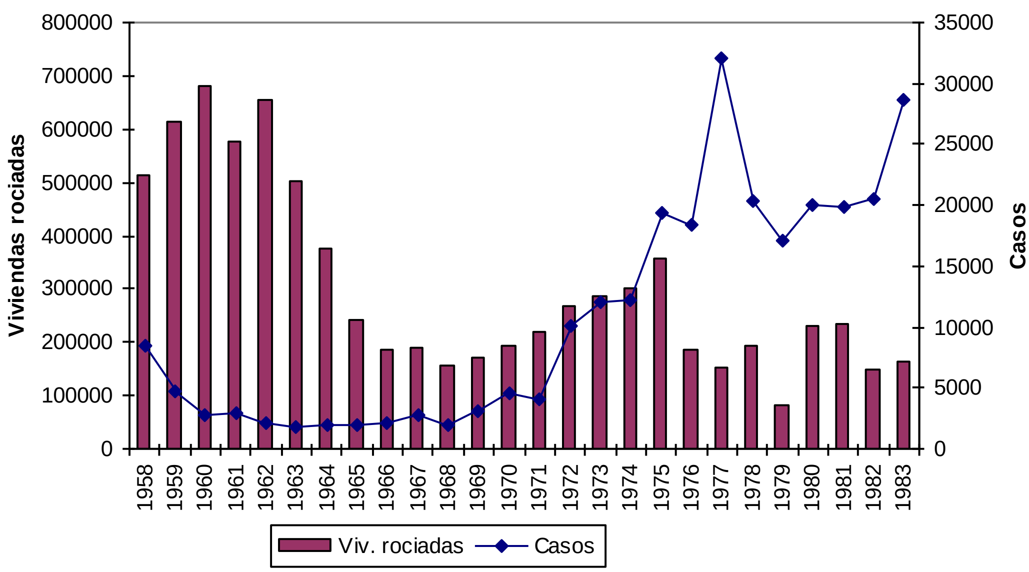

Figure 9: The table above shows that as the number of households sprayed decreased, the number of reported malaria cases increased at the national level.

sprayed with deltamethrin in Aguas Verdes in the first trimester of 2011. However, after this point susceptibility tests showed possible insecticide resistance and IRS was discontinued.

In Loreto, IRS is done twice a year with deltamethrin (5%) in the districts of Requena, Pevas, Ramon Castilla, Indiana, Mazan, Nauta, Intuto, Santa Clotilde and Urarinas. These areas were chosen because they have IPA >10 or because there is a high risk of malaria transmission, and the vector control unit reaches an IRS coverage level of approximately 95%. Before the PPR started in 2011, IRS was done haphazardly, with some districts getting four spray rounds per year, and others getting less. The PPR specifies that IRS should be done twice a year, but given the residuality of deltamethrin (three months), it should be done four times a year. The vector control unit is working with DISA to change the PPR to provide more funds for IRS so it can be done adequately.

Currently, Loreto is implementing a project to do IRS along the Iquitos-Nauta road. The cost of the project is 14,000 soles for 21 people to travel to communities along the highway providing malaria diagnostics and treatment and IRS in households.

As discussed in Section 2.1.3, there is little indication of standardized methodologies for training spray operators or those handling insecticides. The lack of entomological evaluations associated with IRS are discussed further in section 2.3.6b

2.3.2 LARVAL SOURCE MANAGEMENT

A number of challenges exist to ongoing larval source management efforts in Peru:

- Unwillingness of community members to comply with water treatment for larvae with temephos
- Reluctance by farmers in Tumbes to use intermittent irrigation methodology

Larval source management is used only in the control of dengue vectors. In both Tumbes and Loreto, environmental health workers treat standing water with temephos. In Tumbes, water management is privatized, and most households store large quantities of water to ensure a constant supply. Teams of environmental health workers in the region aim to treat 100% of water storage containers in households. They travel to pre-determined areas to distribute temephos sachets to households for all possible *Aedes* breeding sites, systematically distributing sachets in each community. However, many people in the communities do not like the taste of larvicide-treated water and they remove the temephos sachet after the environmental health workers have left. In some cases households will remove the sachets, only to place them back in the water when the environmental health workers are returning for regular monitoring activities.

Whilst this is being done for dengue only, there is an opportunity to use LSM for a wider control of malaria (ref: Section 2.1.6b). This pilot study, which has demonstrated the ability to reduce the density of larvae, presents an opportunity. The methodology of intermittent irrigation of rice fields as also been shown elsewhere around the world in Asia and Africa to be very effective in the right context.

2.3.4 LONG-LASTING INSECTICIDAL NETS

Current barriers relating to the use of long lasting insecticidal nets (LLINs) and their distribution include:

- Lack of government funds to procure and distribute LLINs
- Residual efficacy and usage rates of LLINs distributed by the Global Fund project PAMAFRO in 2007 are unknown
- Ministry of Health has no guidelines for disposal of PAMAFRO nets that are no longer effective

Currently, LLINs are not being distributed in Peru, as DIGESA does not have the financial resources to purchase LLINs for malaria-endemic regions. Previously, approximately 200,000 insecticide treated nets were distributed by MINSA from 1998 to 1999 after El Nino. In addition, 26,185 LLINs were distributed in Loreto from July through September 2007 through the Malaria Control Program in Andean-country Border Regions (also called PAMAFRO) international initiative, which was implemented from 2005 to 2010 by the Global Fund Round 3.

The over-all objective of PAMAFRO was to decrease mortality by 70% and decrease both the number of municipalities with IPA<10 and malaria morbidity by 50%. Participant countries included Ecuador, Colombia, Peru and Venezuela. The specific objectives were to improve community mobilization and access to diagnostics and treatment, improve information systems and epidemiological surveillance. Near the end of the project, LLINs were distributed; however no studies were done to evaluate LLIN usage or the impact of LLINs on malaria cases in the region. DIGESA has expressed interest in performing efficacy tests on the LLINs distributed by PAMAFRO in 2008. Currently the regions are trying to figure out disposal methods for the nets, as some are not longer being used by the communities.

In some areas, such as the region of Tumbes where anopheline mosquitoes are resistant to all insecticides, many people purchase and use un-treated mosquito nets as a personal protection measure.

2.3.5 SPACE SPRAYING

Space spraying is used for dengue control throughout the country. As mentioned above, if regions are in Scenario III of dengue control, meaning that *A. aegypti* is present and there are cases of dengue, in addition to the treatment of water containers, space spray is used for adult control. The insecticide used is the pyrethroid alpha-cypermethrin, which is purchased at the central level by DIGESA and send to the different regions. Space spraying is used in Iquitos for dengue outbreaks. Thermal fogging is also done in Loreto.

2.3.6 INSECTICIDES & ENTOMOLOGICAL MONITORING

Before 1980, coverage with DDT throughout Peru was nearly 100%. With the transfer of resources and equipment to the regions in 1980, insecticide-based vector control coverage began to decrease and cases of malaria began to increase. The use of DDT was prohibited by the WHO in 1990 and pyrethroids began to be used throughout the country. Insecticides are purchased at the national level, and currently the only insecticides purchased are alpha-cypermethrin and cypermethrin, which are used in the case of outbreaks. When DIGESA chooses insecticides for procurement, the INS performs efficacy and susceptibility studies. Only insecticides that have been registered in Peru and are WHOPES-recommended are used for vector control. Local laboratories in Lima perform quality control tests on insecticides that are procured at the national level. INS sometimes performs quality control tests, but only when specifically requested by DIGESA. Insecticides are procured through tenders at the central and regional level, except in the case of emergencies, in which they are purchased directly.

Occasionally, regions purchase their own insecticide when that provided by DIGESA has run out or is no longer available. In this case, DIGESA is unable to advise regions on which insecticides to buy and is unaware of local susceptibility tests conducted before the procurement. Loreto purchases insecticide when the amount supplied by DIGESA runs out, following the same procurement norms and guidelines as DIGESA.

2.3.6a Insecticide Susceptibility/Resistance

A number of challenges to the management of insecticide susceptibility and resistance were found:

- Agricultural interests constrain resistance management
- Difficulty in maintaining *An. darlingi* colonies

- *An. albimanus* are resistant to all insecticides in the north due to selection pressure from insecticides used in rice cultivation
- *Ae. aegypti* are resistant to DDT
- Lack of enforcement for judicious use of pesticides leading to high incidence of misuse of insecticide among rice farmers

Insecticide resistance levels vary throughout the country (Figure 10). The INS evaluates insecticide susceptibility and oversees a network of regional reference laboratories that evaluate insecticide susceptibility in the field. Due to the lack of regional reference laboratories in the south, susceptibility tests are not performed in this area. The INS has found a general lack of understanding in the field as far as causes of insecticide resistance which could contribute to further increases in insecticide resistance levels. For example, in a number of areas, particularly in the north in Tumbes, too much insecticide is often applied under the impression that this will assist in decreasing the mosquito population; however, the mosquitoes are exposed to very high doses of insecticide which serves to increase the development of resistance mechanisms.

In Tumbes *An. albimanus* is resistant to all major classes of insecticides because of pressure caused by

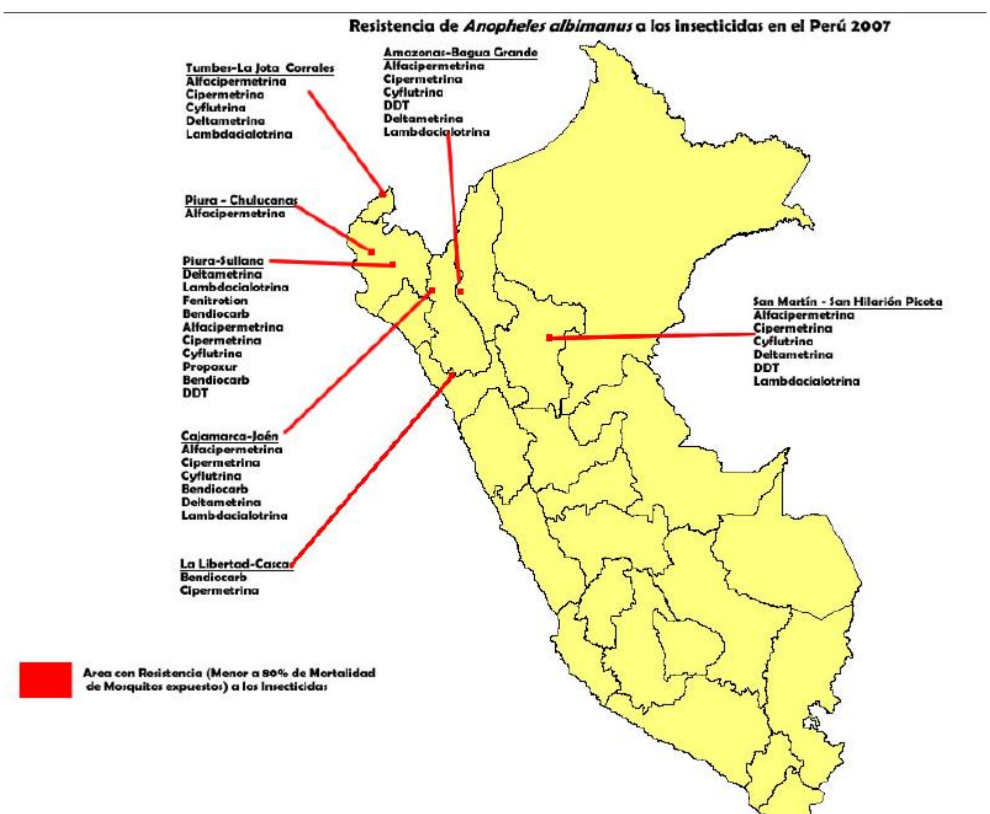

Figure 10: This figure presents the insecticides to which the predominant An. albimanus species in each region is resistant, as found by the regional reference laboratories.

agricultural pesticide use in rice cultivation. *Ae. aegypti* is also resistant to DDT. Those involved in agriculture show little regard for implications of insecticide used in rice cultivation; their primary interest is the healthy development of crops. Because of this, they use any/all insecticides to kill local pests which may harm their crops, not taking into account the effects of pesticides on the local mosquito population. Due to strong agricultural interests, withdrawal of insecticides eliciting resistance in the local vectors is not possible.

2.3.6b Entomological Monitoring

The following challenges to entomological monitoring and surveillance were identified:

- Residual efficacy tests on walls or treated mosquito nets are not performed
- Human landing catches are not always done on a regular basis and it has been difficult to find workers/volunteers to help with the catches
- Entomological monitoring is subject to availability and other priorities for funding

Vector insecticide susceptibility tests are done at two levels. Susceptibility tests following the WHO tube protocol are only conducted at the national level. Of the regional reference laboratories, six regional reference laboratories within Peru have the capacity to conduct susceptibility tests with the CDC bottle assay. These usually are the reference laboratories within the malarious areas. The other regions do not have money to pay mosquito collectors and are therefore unable to conduct susceptibility tests of any type. In order to conduct the bottle assays, the INS sends the necessary diagnostic doses to the regional labs (using dosage levels from the CDC 2010 protocol). In most regions, susceptibility tests are conducted yearly for insecticides used in public health

Currently *residual efficacy tests on walls or mosquito nets* treated with insecticide are not performed for operational purposes (Per. Comm: Pablo Villaseca, INS). Only the INS is in possession of cones to perform these tests, and they only perform cone tests in areas if they specifically ask for them. Some regions have purchased cones, but the cones are not used for efficacy monitoring activities that are reported to the INS. It is possible that they are doing tests for companies with local interests. Efficacy tests for dengue fogging are also not performed.

Human landing catches are used to calculate the main entomological indicators that are reported to the national level. Both local biologists and volunteers are used for the catches at the community level; however, difficulties have been encountered in convincing the volunteers sit and stay awake for 12 hours catching mosquitoes, even though compensation is provided. This could also pose a potential data quality problem if the collectors are not able to stay awake for the entire 12-hour time period. In addition, only Tumbes and Loreto report HLC indicators, while the other regions do not.

In Tumbes vector control activities are decided based on the number of cases, indices and requirements of each region, rather than entomological monitoring and surveillance. This scenario is particularly curious, given that malaria transmission in Tumbes, especially around the rice growing areas has stabilized, as discussed in Section 2.2.1.

In Loreto, human landing catches are programmed to be carried out monthly, but they are not performed because most human resources are used for dengue control. There is also a lack of transport to travel to sentinel sites. In the area of Iquitos, particularly for 2012 as a result of the flooding emergency, there is not funding to pay per diems for field staff (there is an emergency fund, but only for the city of Iquitos).

Entomological monitoring is, however, performed for dengue control. In Loreto, space spraying is conducted in houses where cases are found. Monthly surveillance of larvae occurs in 10% of households in each of the seven provinces; in Iquitos this is done every two months. Technicians also perform resting catches inside houses to measure adult mosquito density with 16 hand-held aspirators.

2.3.6c Sentinel Sites

A network of sentinel sites was developed in 2006 under AMI/RAVREDA to study the behavior of primary malaria vector species. The primary vector species at each site have been identified (Table 2), but currently no further activities are being conducted, nor does DIGESA consider them to be sustainable, primarily because of resource constraints. Entomological monitoring for most of the regions is limited because available resources are diverted to dengue control, and most sentinel sites are non-functional because of lack of resources.

In Tumbes, there are currently two sentinel sites: Aguas Verdes (border area with Ecuador) and San Jose (neighborhood in Tumbes). However, activities in these sentinel sites for malaria vector surveillance are irregular because resources are being diverted to dengue control. The sentinel sites were originally chosen based on the number of malaria cases and presence of breeding sites.

In Iquitos the following sentinel sites are used for human landing catches twice per month: San Juan, Alto Nanay, Mamong, Caballo Cocha, Mazan, Nauta, Requena, and Rio Taluyo. The sentinel sites were chosen because of endemic malaria transmission with a high incidence of cases. While the landing catches are programmed to occur twice a month, this is subject to vector control workers' time

<table>
<tr><th>Department</th><th>Province</th><th>District</th><th>Locality</th><th>Primary Anopheles Vector</th></tr>
<tr><td rowspan="5">Loreto (Iquitos)</td><td>Ramon Castilla</td><td>Caballococha</td><td>Cushillo Cocha</td><td>darlingi</td></tr>
<tr><td rowspan="3">Maynas</td><td>Iquitos</td><td>Lupuna</td><td>darlingi</td></tr>
<tr><td>Mazan</td><td>Libertad</td><td>darlingi</td></tr>
<tr><td>San Juan</td><td>Santa Clara</td><td>darlingi</td></tr>
<tr><td>Loreto</td><td>Nauta</td><td>M. Pacaya</td><td>darlingi</td></tr>
<tr><td rowspan="7">Loreto (Yurimaguas)</td><td rowspan="3">Datem</td><td>Barranca</td><td>San Lorenzo</td><td>benarrochi</td></tr>
<tr><td>Pastaza</td><td>Ullpayacu</td><td>benarrochi</td></tr>
<tr><td>Manseriche</td><td>Saramiriza</td><td>benarrochi</td></tr>
<tr><td rowspan="4">Alto Amazonas</td><td>Lagunas</td><td>Union Campesina</td><td>benarrochi</td></tr>
<tr><td>Teniente Cesar Lopez</td><td>Lago Cuipari</td><td>benarrochi</td></tr>
<tr><td>Balsapuerto</td><td>San Jose de Caballito</td><td>benarrochi</td></tr>
<tr><td>Yurimaguas</td><td>Pampa Hermosa – B. San Juan</td><td>benarrochi</td></tr>
<tr><td rowspan="4">San Martin</td><td>Lamas</td><td>El Pongo</td><td>Sta. Rosa de Tioyacu</td><td>benarrochi</td></tr>
<tr><td>San Martin</td><td>Tarapoto</td><td>Chontamuyo</td><td>albimanus</td></tr>
<tr><td>Moyobamba</td><td>Moyobamba</td><td>Yantalo</td><td>benarrochi</td></tr>
<tr><td>Picota</td><td>San Hilarion</td><td>San Hilarion</td><td>albimanus</td></tr>
<tr><td rowspan="4">Tumbes</td><td>Zarumilla</td><td>Aguas Verdes</td><td>Villa Primavera</td><td>albimanus</td></tr>
<tr><td rowspan="3">Tumbes</td><td>Corrales</td><td>San Isidro</td><td>albimanus</td></tr>
<tr><td>San Juan de la Virgen</td><td>Cerro Blanco</td><td>albimanus</td></tr>
<tr><td>Tumbes</td><td>Las Malvinas</td><td>albimanus</td></tr>
<tr><td rowspan="3">Madre de Dios</td><td rowspan="2">Tambopata</td><td>Inambari</td><td>Santa Rita</td><td>darlingi</td></tr>
<tr><td>Colorado</td><td>Bajo Puquiri</td><td>darlingi</td></tr>
<tr><td>Manu</td><td>Huepetuhe</td><td>Choque</td><td>darlingi</td></tr>
</table>

Table 2: This table lists the 23 sentinel sites for entomological surveillance in Peru by department, province, district and locality.

availability and DISA funding availability for payment of per diem.

2.3.7 INTERSECTORAL COLLABORATION

The primary challenges to intersectoral collaboration in Peru include:

- Lack of an institutional framework for intersectoral collaboration
- Regions are unaware of intersectoral collaboration in other regions and cannot learn from their example, as current successful activities are not well-documented and publicized

There is no formal institutional framework for collaboration, which is currently ad hoc and based on coinciding interests. However there are instances where Ministry of Health (MINSA) and Ministry of Agriculture collaborate. One such instance is the intermittent irrigation of rice fields in the north. The Ministry of Agriculture and MINSA worked together encourage the use of the intermittent irrigation methodology, with the Ministry of Agriculture providing education and support to local rice growers. This resulted in MINSA signing a resolution in 2010 approving the use of intermittent irrigation as a proven method to decrease mosquito populations and thereby decrease local levels of malaria transmission.

In Tumbes DIRESA is working with the education sector to include vector control in the primary school curriculum. It is unknown whether DIRESA is working with the Ministry of Education, or whether they are only working with specific local schools rather than trying to target the educational system throughout the region.

2.3.8 COMMUNITY MOBILIZATION

A number of challenges to current community mobilization efforts were identified, including:

- Lack of community mobilization for vector control in Tumbes, where community members do not comply with on-going vector control interventions, such as larviciding
- Misconceptions regarding the role of environmental health workers

Community mobilization activities vary widely from region to region because of decentralization. In Tumbes, community mobilization is done by the Health Promotion Department rather than by the vector control sector. There is currently a local television campaign for dengue control that encourages communities to wash water tanks and cover them so that *Aedes* are unable to reproduce. Vector control techniques are discussed with students in 222 schools throughout the region. Community mobilization in Tumbes is occasionally difficult because many people do not like or are unable to read, making it difficult to provide printed educational materials in the communities. Each year there is a community-wide collection of discarded containers. In addition, there is a network of community volunteers at the local level that take blood samples (thick smears) for malaria and take the samples to the laboratory or local health point; as payment they receive free national health insurance.

At the community level in Loreto and Tumbes, there are misconceptions about the role of the environmental health workers. Residents believe it is the health worker's responsibility to clean water storage containers; health workers waste valuable time when they could be performing vector control activities scrubbing out plastic barrels and cement water storage containers.

2.3.9 SPECIAL CIRCUMSTANCES

2.3.9a Border Collaboration & Mining Areas

In both border and mining areas, populations are difficult to access either because of dangerous conditions such as narco-trafficking, lack of infrastructure to facilitate access, or because the populations living in those areas would prefer to remain unrecognized. There is a risk of both imported disease (such as Yellow Fever) and disease outbreaks in these areas because the residents do not seek treatment and local health workers are unable to access these areas. To this end, Peru has a border agreement with Ecuador to perform collaborative interventions and joint trainings. In 1991, a three-party agreement was signed

Figure 11: This figure presents the border collaboration area among Brazil, Peru, and Colombia.

between Brazil, Colombia, and Peru to provide health services, including vaccinations, HIV/AIDS prevention, and malaria control (Figure 11).

Along the Colombian border in the Loreto region, *P. falciparum* and *P. vivax* are both prevalent, but this area is difficult and dangerous to enter. DISA has only been able to enter this area three times, during which they used a loud speaker to tell community members with malaria to come out for treatment. Organized vector control for neither malaria nor dengue is implemented in this area.

3.0 OPPORTUNITIES FOR ADDRESSING VECTOR CONTROL CHALLENGES

3.1 STRENGTHENING INTERSECTORAL COLLABORATION FOR VECTOR CONTROL

As mentioned in Section 3.2.7, some of the primary challenges to intersectoral collaboration in Peru include:

- Lack of an institutional framework for intersectoral collaboration
- Regions are unaware of intersectoral collaboration in other regions and cannot learn from their example, as current successful activities are not well-documented and publicized

There is no formal structure for intersectoral collaboration, and most cases of collaboration arise from coinciding interests, such as the MINSA and Ministry of Agriculture promotion of intermittent irrigation of rice fields to decrease malaria transmission along the Pacific coast in northern Perú

This intersectoral collaboration between the health and agriculture ministries has been successful in some departments, in which health authorities have worked with agronomists and agronomic engineers to explain to the farmers the possibility of managing their rice crops with the intermittent flooding methodology. The support of agricultural experts is crucial for the farmers, as they need to be reassured that they will not suffer a decrease in crop output due to the new flooding scheme. For malaria, the results have been encouraging; the density of *An. albimanus* and malaria transmission rates have shown important reductions.

It would be worthwhile to document the lessons from this collaboration to highlight the need to formalize/create similar structures. Even though MINSA signed a resolution approving (and encouraging) the use of intermittent irrigation for malaria control, the methodology still is not being used in many areas where it would be relevant. In Tumbes, for example, farmers are hesitant to start using the new methodology. Some farmers tried to use intermittent irrigation but they were not supported by agricultural efforts and the final rice output was much lower than expected. A pilot project with the Ministry of Agriculture would advance the understanding and usage of the intermittent irrigation methodology in Tumbes, and other regions in northwestern Peru. It will be important to design the pilot project so it can be measured effectively and the critical lessons recorded locally, to the advantage of both Peru and other AMI countries facing similar situations. While initial lessons have been published in the MINSA document "Implementation Plan for the Intermittent Irrigation in Rice Cultivation Strategy for Malaria Vector Control in Prioritized Regions in Peru", it is not widely disseminated within Peru and other AMI countries may not be fully aware of this opportunity.

3.2 STRENGTHENING HUMAN RESOURCES AND SYSTEMS FOR VECTOR CONTROL

3.2.1 Strengthening communication

The primary challenges to communication between the regional and central level are:

- Central level is not involved in decision-making at the regional level and funding is sent directly to the regions with little to no input from the central level
- Central level is unaware of activities and research opportunities occurring at the regions which could be used to drive strategies at the national level

One of the impacts of decentralization has been a lack of communication between central and regional levels. As the budget is sent to each region, and the regions make decisions regarding funding and work plans, and the central level is left out of most decisions. However, when the regions face outbreaks or other difficulties, they go to the central level (DIGESA or the INS) for advice and counseling. From the viewpoint of the central level, this situation could be improved and, in some cases, those difficulties might be prevented if the communication were more frequent. The strategy of "Budgeting for Results" (PPR), in which the planning is linked to the budget assigned to each region, the regions must show the execution of the activities planned. This, in some cases, has helped to overcome the difficulties in communication, however additional steps are still needed.

One of the aspects in which improvement of communication is necessary is in research. The country has several research institutions working on vector borne diseases. Whilst at the regional level there seems to be a high level of communication between research institutions and the communities in which they conduct research, the same cannot be said for communication between the regions and the central level. The central level is often not adequately informed of research occurring in the regions. This results in lost opportunities where information could be synthesized at the central level to drive strategies. A case in point would be intermittent irrigation, where the results compiled by the central level have not been adequately distributed to the regional level   At the central level little is known what the regional or national universities, as well as other research institutions, are doing or their results. Some of the more practical research projects could have a great impact on the policy-making direction for MINSA. Improvement in the communication regarding research in vector borne diseases is highly recommended and desirable.

3.2.2 Vector control workforce

There are a number of challenges relating to personnel involved in vector control at both the upper and lower levels in some regions, including:

- Lack of environmental health workers in peripheral areas in Tumbes
- High staff turnover results in loss of institutional memory and experience

In Tumbes, all environmental health workers are located at the central level, which makes work in the rural communities more costly in both time and resources. The inadequate placement of staff, especially in peripheral areas, impacts vector control activities because there is no one at the community level to ensure that households comply with interventions, such as larviciding.

In Tumbes, there is a network of community volunteers at the local level that take blood samples (thick smears) for malaria, which they then take to the laboratory or local health point. As payment for their assistance, the volunteers receive free national health insurance. This needs to be studied further to see how such volunteer arrangements could be extended for work in vector control. It would be possible to provide information to the community volunteers on the role of vector control in vector borne disease prevention, and they could serve as a local vector control focal point as they are already located within the communities.

Within both the central and regional levels of government in Peru, there is high staff turnover which results in loss of institutional memory and experiences. For example, in the case of the region of Loreto at the time this VCNA was conducted, the Executive Director of DIGESA had only been at his post for two months and there was a likely probability that a new person would be named for his position in the very near future, as new executive directors were currently being appointed throughout the region. It is difficult to effect positive change when job security is uncertain, and this also results in a loss of valuable experiences and knowledge in region-specific information and peculiarities. Given the high level of turnover at upper levels in the government, it is important that future capacity building and training efforts be aimed at environmental health workers, regional reference laboratory staff, and technicians (rather than their superiors), as these personnel are less likely to be reappointed with each new administration.

3.2.3 Enhancing intervention monitoring

The primary challenges relating to monitoring and evaluation of vector control interventions during the VCNA include:

- Lack of resources generally for vector control for maintenance of critical infrastructure and monitoring operations
- Competition for use of human and financial resources with dengue, which is increasing
- Lack of residual efficacy tests for insecticides sprayed on wall surfaces for operational purposes
- Absence of knowledge about residual efficacy of long-lasting insecticidal nets (LLINs) in field conditions
- Irregular reporting of entomological indicators

Insecticide efficacy evaluations should be established and conducted regularly to better assess the effectiveness of IRS and LLINs for malaria control in Peru. Some of these activities are currently being carried out for local businesses. As such, there may be an opportunity to see if private sector entities could be interested from a perspective of corporate social responsibility to work together with vector control programs.

While the capacity exists at the national level at the INS and within the regional reference laboratories, residual efficacy monitoring tests are not performed on a regular, operational basis in any regions of Peru where IRS is regularly conducted. In Loreto, IRS with deltamethrin is conducted several times a year in various districts throughout the region with high malaria burden (ref: Section 2.3.1). While the presumed average residuality of deltamethrin in Loreto is 3 months, no data is available on the actual residuality of deltamethrin on various surfaces in the communities. Residual efficacy tests can also be used to check the quality of the spray operations to ensure that each household is adequately protected.

In addition, the residual insecticidal effect of the 26,285 LLINs distributed by the Global Fund-implemented PAMAFRO project from July through September 2007 has never been evaluated. DIGESA has stated that they are trying to obtain funding to perform these bioassays, which would be crucial to the further implementation of LLINs as a malaria control measure in Peru. Even though efficacy tests were not conducted consistently throughout the life of the nets, it would be useful to see what insecticidal effect still remains and to observe the general condition of the LLINs after several years of operational use. These bioassays would also provide DIGESA/DIRESA a valuable opportunity to learn more about community perceptions of the nets over time. The information gathered would inform future LLIN procurement and also implementation and information, education and communication/behavior communication change strategies.

Currently, the INS only performs residual insecticide efficacy tests if specifically requested by DIGESA. Many of the regions already have cones and are knowledgeable of the protocol for efficacy testing, as they perform residual efficacy tests for local insecticide companies. The INS also has a susceptible strain of mosquitoes (*An. albimanus* “Sanarate”) and malaria-endemic regions have functional insectaries within the regional reference laboratories; regional colonies of “Sanarate” mosquitoes could easily be cultivated for a constant stock of susceptible mosquitoes for insecticide efficacy tests in endemic areas where *An. albimanus* is present. In other departments like Loreto, where this species is not present, collections of field mosquitos is necessary (i.e. *An. darlingi* or *An. benarrochi*) to carry out the tests. NAMRU-6 in Iquitos has expressed interest in helping the regional reference laboratory to cultivate susceptible mosquito colonies to perform the efficacy tests.

In addition, there is the possibility of increased funding for entomological monitoring and surveillance through the PPR budgeting tool, as discussed in Section 2.1.5.

There needs to be a systematic approach to mobilize the private sector to support activities, noting that malaria impacts negatively on productivity. The toll caused by malaria on productivity should be a main concern for companies and businesses operating in malaria-endemic areas. The development of a framework for vector control and entomological monitoring and surveillance would allow both the central and regional levels to identify human and financial resources necessary for a successful vector-borne disease control program. Comparing these resources with those that local business may have to offer would optimize local resource mobilization for vector control and surveillance

Current training and refresher courses are ad hoc and non-standardized. The current tools available, such as the entomology manual and standardized entomology videos developed by the IVM Project, need to be made available to those working in the field, performing interventions and entomological monitoring. There is a need for a standardized curriculum and certification (ref: Section 2.3.1) to encourage people to undergo training

3.2.4 Opportunities for community mobilization

Community involvement is necessary for the sustainable and effective implementation of any vector control intervention. The following challenges to community mobilization were identified during the VCNA:

i. Misunderstanding at the community level over their role their role in vector control

ii. Lack of compliance with vector control interventions implemented by health workers

While DIGESA and DIRESA have funded a number of community mobilization campaigns, including television informational commercials on dengue prevention (these commercials stress the importance of throwing away unused containers, cleaning water basins, allowing technicians to do space spraying, etc.) and the distribution of calendars illustrating methods for dengue larval control, in some regions of Peru there is very little involvement within the communities themselves. In both the regions of Loreto and Tumbes, households expect environmental health workers to clean water storage containers. In Tumbes, many households remove the temephos sachets used for dengue larval control after the environmental health workers have applied them to containers of standing water, only to place them back in the water when they know the workers are coming back.

The existing community mobilization campaigns are either not reaching the communities, or the community members are choosing to ignore the messages. A possible solution would be to target school children with vector control-specific messages. In Tumbes, vector control is included in the primary school curriculum, yet environmental health workers are still encountering challenges in cooperation with vector control interventions. There needs to be a concerted country-wide effort with the involvement of DIGESA and the central Ministry of Education to include vector control messages in schools.

In the north, the use of citronella-based repellants (which are available in the area) could assist in decreasing the number of mosquito bites if families thought there was added value in purchasing them. Human resource capacity exists in both Loreto and Tumbes to provide this sort of education in schools. In Loreto, vector control technicians located throughout the provinces could approach local schools with information on vector control. Each health center in Loreto also has a health promoter who could work with local schools. While there are no environmental health workers placed at the local level in Tumbes, the regional workers travel regularly to the field. They could also work with local schools to educate students and their families on vector control. Teachers and local health promoters, familiar with local traditions and idiosyncrasies, would be able to frame vector control information in a way that would be culturally acceptable and that each community would understand. It would also be possible to supplement the in-school curriculum with weekly programs on malaria/dengue or vector control with questions and answers for both the students and teachers.

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