ENTOMOLOGICAL MONITORING, ENVIRONMENTAL COMPLIANCE, AND VECTOR CONTROL CAPACITY

FOR THE PREVENTION OF ZIKA AND OTHER ARBOVIRUSES

EL SALVADOR

ASSESSMENT REPORT

September 2016
This publication was produced for review by the United States Agency for International Development. It was prepared by Juan I. Arredondo-Jiménez and Alan Wheeler for the Health Finance and Governance Project.

The Health Finance and Governance Project
USAID's Health Finance and Governance (HFG) project improves health in developing countries by expanding people's access to health care. Led by Abt Associates, the project team works with partner countries to increase their domestic resources for health, manage those precious resources more effectively, and make wise purchasing decisions. As a result, this five-year, $209 million global project increases the use of both primary and priority health services, including HIV/AIDS, tuberculosis, malaria, and reproductive health services. Designed to fundamentally strengthen health systems, HFG supports countries as they navigate the economic transitions needed to achieve universal health care.

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CONTENTS

Acronyms

BCC	Behavior change communication
Bti	*Bacillus thuringiensis* var. *israelensis*
COMISCA	*El Consejo de Ministros de Salud de Centroamérica*
ECOS	Community health teams (*Equipos Comunitarios de Salud Familiar y Especializados*)
EPA	Environmental Protection Agency
EW	Emulsion, oil in water
GIS	Geographic information system
HFG	Health Finance and Governance project
IEC	Information, education, and communication
IRS	Indoor residual spraying
LAC	Latin America and the Caribbean
MINSAL	Ministry of Health (*Ministerio de Salud*)
PAHO	Pan American Health Organization
PPE	Personal protective equipment
SC	Suspension concentrate
QA	Quality assurance
SIBASI	*Sistema Básico de Salud Integral*
USAID	United States Agency for International Development
WHO	World Health Organization

EXECUTIVE SUMMARY

The first case of local, vector-borne transmission of the Zika virus in the Americas was identified in May 2015 in Brazil. By July 2016, the virus had spread to nearly all Zika-suitable transmission zones in the Americas, including the majority of countries and territories in the Latin America and the Caribbean region. Governments in the region face a formidable challenge to minimize Zika transmission and limit the impact of Zika on their populations.

The United States Agency for International Development (USAID) supports efforts to strengthen the region's Zika response through targeted technical assistance, stakeholder coordination, and implementation of key interventions. In El Salvador, the USAID-funded Health Finance and Governance project assessed country capacity to conduct vector control and entomological monitoring of *Aedes* mosquitoes, the primary vector of the virus. The assessment was conducted from July 11 to July 21, 2016, and sought to gauge current capacities, identify strengths and weaknesses in these capacities, and recommend countermeasures, i.e., specific strategies to minimize the impact of Zika virus transmission.

The first case of Zika in El Salvador was reported in November 2015. By mid-2016, nearly 7,000 cases were reported, 255 by pregnant women. Since the beginning of the epidemic, 318 pregnant women were clinically diagnosed with Zika, a few of which were also laboratory confirmed. While microcephaly has not appeared in significant numbers, Guillain-Barré Syndrome has, with 118 documented cases as per a report from February 2016.

In 2014, a national-level arbovirus steering committee was formed following the appearance of chikungunya. In response to the confirmation of autochthonous Zika transmission in the country in late 2015, the committee began to convene weekly to review available data and provide technical guidance for the Zika response. The Ministry of Health (MINSAL) coordinates the activities of all stakeholders involved in the response, and maintains an online database with epidemiological and entomological data that guides the planning and implementation of Zika mitigation actions.

MINSAL leads an integrated approach to vector management in the country, using a combination of chemical, biological, and physical control methods. These efforts are complemented through public engagement and mobilization, the goal of which is to encourage communities to reduce mosquito breeding sites. There is a wide range of entomological surveillance measures routinely carried out that includes species composition of Zika vectors, their distribution, and their seasonality. Due to the short duration of the assessment, the team was not able to directly verify data collection and handling in the field and are thus the quality of the data. The data appeared comprehensive in terms of quantity and coverage; coming on a weekly basis from sources across the country. Family health teams are engaged in these measures, and collect data related to surveillance and control at the community level. The online database greatly facilitates the analysis of data and ensures access to weekly epidemiological bulletins to anyone with a web connection.

El Salvador has various strengths that position the country to respond to some of the challenges posed by arboviral vectors. A number of issues were also identified that hinder a more credible response to Zika, and likely to future arboviral epidemics as well. These include:

1. **Insufficient funding for management of Zika-transmitting vectors.** Aside from funding set aside for procurement of insecticides, MINSAL's Vector Control Division lacks a specified budget to conduct vector surveillance and vector control activities, and to keep adequate equipment and supplies on hand.

2. **Limited capacity for quality assurance and entomological studies.** Due to the lack of a quality assurance (QA) system for surveillance data collection, the accuracy and completeness of source data for surveillance is unclear. The absence of a reference entomology laboratory and associated insectary facilities prevents routine resistance testing of larvicides and adulticides and the monitoring and evaluation of chemical-based intervention methods. El Salvador cannot investigate the effectiveness of new chemical products, review resistance mechanisms in local *Aedes* populations, or carry out fundamental research studies into the behavior and ecology of mosquitoes.
3. **Potential resistance to insecticides in use among Zika vectors.** While the current status of pyrethroids used for routine control activities remains unknown, it is likely that *Aedes aegypti* exhibits a high degree of resistance to these chemicals. Local populations have been shown to be resistant to temephos, yet it is still in use probably a result of its relatively low cost.
4. **Over-reliance on vector control methods that are likely ineffective.** The primary method for applying adulticides in El Salvador appears to be via thermal fogging. While thermal fogging is effective at killing adult mosquitoes, it provides no residual effect and is essentially a short-impact intervention method. Indoor residual spraying (IRS) using compression spray or mist-blower equipment would likely provide a longer-lasting residual effect.
5. **Substandard practices related to insecticide and equipment management.** Chemical storage facilities in El Salvador are mostly inadequate, and lack basic elements critical to storing and maintaining chemical and biological products, as well as equipment to guarantee the safety of staff. There is no plan in place for the handling, transport, use, and disposal of insecticides.

Based on these findings, the assessment team recommends that the Government of El Salvador, in conjunction with donor agencies, should:

1. **Ensure that sufficient funding is dedicated for management of Zika-transmitting mosquitoes.** Comprehensive vector control in El Salvador requires more funds than are currently allotted. Line item budgets should detail procurement of insecticides, equipment, and safety supplies such as personal protective equipment. Additional funding should be made available for dissemination of behavior change communication materials to promote improved personal protection, as well as source reduction and environmental management.
2. **Establish a national-level insectary and insecticide testing facility.** Establishment of a functional insectary would not require extensive or highly advanced equipment, nor would it merit new construction. Similarly, a reference laboratory could be established at minimal cost, allowing El Salvador to conduct a range of activities, from basic morphological identification to more complex techniques such as determination of resistance mechanisms.
3. **Determine the resistance status of the local *Aedes aegypti* population.** To maximize the effectiveness of vector management activities, the generation of data on resistance status remains an imperative. This should include a review of insecticides currently in use and those that could be used in the future. Based on reported resistance of local vectors to temephos, alternative larvicides should be explored and targeted for registration for use in El Salvador. While a*egypti* is of primary importance but it would be useful to include data on *Aedes albopictus* and any other potential vector species.
4. **Design and implement an insecticide resistance management plan.** Results from resistance studies should be used to design an insecticide resistance management plan that includes mitigation approaches such as rotations of insecticides from different chemical classes.
5. **Employ alternative methods for vector management.** Given the suspect efficacy of thermal fogging, alternative methods should be determined, tested, and eventually put into use

to reduce arboviral vector populations. This could include IRS adapted for urban environments and outdoor perifocal treatments. If fogging is to be continued, current equipment in use should be substituted for portable mist-blowers and truck-mounted cold fogging machines.

6. **Develop an environmentally compliant insecticide management strategy and refurbish the main pesticide facility in San Salvador**: The government should prioritize the development of an insecticide management strategy that aligns with internationally accepted guidelines, and establishes management procedures to protect the safety of individuals that may be exposed to such products.

7. **Implement a countrywide QA system for surveillance data collection and vector control operations.** A QA system for surveillance data is critical to all the preceding recommendations. The QA system would entail routine visits by senior entomologists to all vector control units within El Salvador to ensure that all data collected conformed to similar standards and quality. This system would ensure that recommendations were implemented and also enable continual improvement. Donors should consider supporting a Vector Control QA Officer whose role is to support the implementation of a QA system for data collection, identify weaknesses in vector management efforts, and provide on-site troubleshooting support.

1. INTRODUCTION

The Zika virus was first isolated in 1947 from a rhesus monkey in the Zika forest of Uganda. The earliest human Zika cases were detected in 1952, yet it was not until 1964 that Zika was confirmed to cause human disease. Over subsequent decades, evidence of Zika emerged in numerous countries outside of east Africa, yet documented human cases were rare until a 2007 outbreak in Yap, Micronesia. Prior to 2015, there was no confirmation of Zika virus circulation in the Western Hemisphere.[1] The first case of local, vector-borne transmission of the Zika virus in the Americas was identified in Brazil in May 2015. By the end of July 2016, autochthonous cases had been diagnosed in the majority of countries and territories in the Americas and nearly all of the Latin America and the Caribbean (LAC) region. [2,3]

As Zika continues its rapid proliferation throughout the LAC region, national and local governments face a daunting task to control its spread and minimize its impact. The United States Agency for International Development (USAID) is supporting the Zika response in the region across four key technical areas: service delivery, including maternal and child health, family planning, and child development; social and behavior change communication; innovation; and vector control. Through targeted technical assistance, USAID's vector control efforts aim to strengthen national vector control programs, catalyze community mobilization to eliminate mosquito breeding sites, and facilitate the procurement and promotion of repellents for personal use.

To gauge the readiness of governments in the region to respond to Zika and other vector-borne diseases, the USAID-funded Health Finance and Governance (HFG) project assessed country capacity to conduct vector control and entomological monitoring of *Aedes* mosquitoes, the primary vector of the virus. Assessments were carried out in five countries in the region: the Dominican Republic, El Salvador, Guatemala, Haiti, and Honduras, in June and July of 2016. They were designed to focus on nine elements of national and subnational capacity:

- Place, Structure, and Financial Resources of Entomological Surveillance and Vector Control at Various Administrative Levels
- Stakeholders' Coordination and Community Mobilization /Engagement for Control of *Aedes* Mosquitoes
- Human Resources
- Infrastructure
- Capacity to Design and Prepare Entomological Monitoring, Vector Control, and Environmental Control Plan
- Implementation Capacity
- Data Collection, Analysis, and Reporting
- Stakeholders' Engagement and Use of Entomological Data to Inform Vector Control
- Insecticide Registration Status and Environmental Compliance

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1 http://www.who.int/emergencies/zika-virus/history/en/
2 http://www.paho.org/hq/index.php?option=com_content&id=11599&Itemid=41691.
3 http://www.floridahealth.gov/diseases-and-conditions/zika-virus/.

HFG drafted a capacity assessment tool, comprised of the nine elements of national and subnational capacity, and then modified it based on feedback from USAID (see Annex A for the assessment tool). In each of the five assessment countries, a two-person team used the tool through semi-structured interviews with individuals involved in or knowledgeable of vector control and entomological monitoring in the country. In addition to data gathered using the assessment tool, the teams collected and reviewed secondary data to aid in the contextualization of Zika and the Zika response in each of the target countries.

The assessment in El Salvador took place from June 14 to 25, 2016. The assessment team interacted with various stakeholders including representatives from the following institutions and organizations:

- Ministry of Health of El Salvador (*Ministerio de Salud, MINSAL)*
- Civil Protection Unit, Ministry of the Interior
- Community Health Team (*Equipos Comunitarios de Salud Familiar y Especializado, ECOS*)
- USAID/El Salvador
- *El Consejo de Ministros de Salud de Centroamérica (COMISCA)*
- Pan American Health Organization (PAHO)
- United Nations Children's Fund (UNICEF)
- United Nations Population Fund (UNFPA)

See Annex B for a complete list of contacts made by the assessment team, including organizational affiliation, and title/role.

2. Situation Analysis

2.1 Situation of Zika and Other Arboviral Diseases in El Salvador

El Salvador is located along the Pacific Coast of Central America, and borders Guatemala and Honduras. It has a total population of 6,250,000 according to 2015 estimates within a territory of 21,041 Km^2, making it one of the most densely populated countries in the Americas (309 inhabitants/Km^2).[4] The entire population is at risk of Zika and other arboviral diseases, as the primary mosquito vectors, *Aedes aegypti* and *Aedes albopictus*, are widely present throughout the country.

Zika virus was first detected in El Salvador in 2015. As of epidemiological week 26 of 2016, 6,924 suspected cases of the virus were reported, 43 of which were laboratory confirmed. Of the nearly 7,000 reported cases, 255 were pregnant women.[5] Since the beginning of the epidemic in El Salvador, in late 2015, 318 pregnant women were clinically diagnosed with Zika, some of which were laboratory confirmed. Of these, six women gave birth and one newborn was confirmed to have microcephaly. Guillain-Barré Syndrome associated with Zika has also been found in the country. A report from February 2016 documented 118 cases of Guillain-Barré Syndrome in El Salvador.[6]

Other arboviruses transmitted by *Aedes aegypti* are also prevalent in El Salvador, including dengue and chikungunya. As of epidemiological week 26, a total of 5,285 suspected cases of chikungunya virus were recorded (none were laboratory confirmed), reflecting a 76 percent reduction in reported cases compared to the same period in 2015. Only 159 cases led to hospitalization, an 86 percent reduction compared to 2015; no deaths were reported.

Over the same period, 6,045 suspected cases of dengue were reported, 65 of which were laboratory confirmed. The 6,045 cases represented a 38% reduction compared with 2015. A total of 1,044 hospitalizations related to dengue occurred, at a 34% reduction from the previous year, with one confirmed death.

The vast majority of suspected cases of Zika, chikungunya, and dengue were not laboratory confirmed – only 108 out of 18,254 suspected cases (0.6%) were confirmed. Due to the similarity of clinical symptoms among these diseases, it is highly probable that some cases were misdiagnosed. As a result, both the reduction in reported dengue and chikungunya cases from 2015 to 2016, as well as the increase in Zika cases over that period may be inaccurate. Nevertheless, the high number of reported cases of the three diseases, along with the failure of widespread laboratory confirmation, highlights the vulnerability of El Salvador to arboviral diseases.

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[4] http://www.digestyc.gob.sv:8003/index.php?option=com_phocadownload&view=category&id=36&Itemid=200

[5] http://www.salud.gob.sv/download/boletin-epidemiologico-semana-26-del-26-de-junio-al-2-de-julio-de-2016/

[6] http://apps.who.int/iris/bitstream/10665/204514/1/zikasitrep_19Feb2016_spa.pdf

2.2 Vectors of Arboviral Diseases and their Distribution in El Salvador

In the Americas, *Aedes aegypti* has long been considered the primary vector of all four serotypes of dengue, as well as chikungunya and Zika viruses.[7,8] Although *Aedes albopictus* is also suspected as a vector of these arboviruses, *Aedes aegypti* is considered to be the more appropriate target for control efforts due to its closer association with man and its tendency to feed more on humans than *Aedes albopictus*.[9]

Aedes aegypti generally prefer breeding sites such as manmade containers found in and around households. *Aedes albopictus* is considered a more peridomestic mosquito, found in semi-urban environments with a wider variety of breeding sites that include small containers left in extra-domiciliary sites (e.g. discarded buckets, cans, trays, etc.), in addition to natural habitats such as tree holes, bromeliads, and rock holes. Observed preferences for breeding sites for both species may not be due to resource partitioning,[10] but rather to the proximity of their preferred hosts.[8] *Aedes aegypti* is commonly found at elevations as high as 1,700m[11] and is therefore thought to be widespread across most of El Salvador, apart from its highest volcanic peaks.

2.3 Vector Control Interventions in El Salvador

MINSAL implements an integrated approach to vector management in the country, using a combination of chemical, biological, and physical control methods. These approaches include application of larvicides and adulticides. No data were provided to indicate the quantities of insecticide applied, though approximately US$1 million is spent on insecticides per year. Biological control interventions are based around the distribution of larvivorous fish that can be placed in permanent water storage tanks, yet the reach is limited to only a handful of localities. Although this has been shown to be effective in some countries,[12] no data are available on its effectiveness in El Salvador, and the coverage in terms of residences utilizing this technique remains unknown.[13]

Despite a wide range of larvicides available (biological, bio-rational and/or chemical), the only larvicide to control *Aedes aegypti* used in El Salvador is the organophosphate temephos, which is applied as a 1% granular formulation. This larvicide, which involves direct application to water-holding containers, has been recommended by the WHO for application to drinking water.[14] Temephos' efficacy when mosquitoes are susceptible, its residual effect, and its low cost have resulted in it being the larvicide of choice in El Salvador. Unfortunately, temephos continues to be applied despite evidence of high levels of resistance recorded in Soyapango, San Salvador Metroplitan area (i.e. Resistance Factor 50 RF_{50}=24).[15]

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[7] Rodriguez-Morales AJ, Villamil-Gómez WE, Franco-Paredes C. The arboviral burden of disease caused by co-circulation and co-infection of dengue, chikungunya and Zika in the Americas. Travel Med Infect Dis. 2016;14(3):177-179.

[8] Porrino P. Zika virus infection and once again the risk from other neglected diseases. Trop Doct. 2016;46(3):159-165.

[9] Sivan A, Shriram AN, Sunish IP, Vidhya PT. Host-feeding pattern of *Aedes aegypti* and *Aedes albopictus* (Diptera: Culicidae) in heterogeneous landscapes of South Andaman, Andaman and Nicobar Islands, India. Parasitol Res. 2015;114(9):3539-3546.

[10] Fader JE, Juliano SA. Oviposition habitat selection by container-dwelling mosquitoes: responses to cues of larval and detritus abundances in the field. Ecol Entomol. 2014;39(2):245-252.

[11] Lozano-Fuentes S, Hayden MH, Welsh-Rodriguez C, Ochoa-Martinez C, Tapia-Santos B, Kobylinski KC, Uejio CK, Zielinski-Gutierrez E, Monache LD, Monaghan AJ, Steinhoff DF, Eisen L. The dengue virus mosquito vector Aedes aegypti at high elevation in Mexico. Am J Trop Med Hyg. 2012;87(5):902-909.

[12] Han WW, Lazaro A, McCall PJ, George L, Runge-Ranzinger S, Toledo J, Velayudhan R, Horstick O. Efficacy and community effectiveness of larvivorous fish for dengue vector control. Trop Med Int Health. 2015;20(9):1239-1256..

[13] http://www.radioworld.com.sv/utilizan-pequenos-peces-para-combatir-el-zika-en-el-salvador/

[14] http://www.who.int/whopes/Mosquito_Larvicides_Sept_2012.pdf

[15] Lazcano JA, Rodríguez MM, San Martín JL, Romero JE, Montoya R. Evaluación de la resistencia a insecticidas de una cepa de *Aedes aegypti* de El Salvador. Rev Panam Salud Publica. 2009;26(3):229-234.

The U.S. Environmental Protection Agency (EPA) recently discontinued the registration of temephos as a larvicide for domestic use in the United States. [16] However, it is still recommended by the WHO. No newer larvicides, such as *Bacillus thuringiensis* var. *israelensis* (Bti), spinosad, pyriproxyfen, or methoprene, are currently being used in El Salvador.

The primary method for applying adulticides in El Salvador is via thermal fogging. While thermal fogging is effective at killing adult mosquitoes, and may kill some larvae if it falls on breeding sites, it provides no residual effect and is essentially a short-duration intervention method.[17] As it is, the lethal effect on adult mosquitoes is expected while the insecticide is suspended in the air and is lost when it falls to the ground or drifts. The adulticides used in the country are synthetic pyrethroids, namely permethrin (i.e. EW formulation [emulsion, oil in water), and deltamethrin (i.e. formulations EW and SC [suspension concentrate]). Both insecticides are applied at standard dosages, 10g and 1g active ingredient/Ha, respectively, for permethrin and deltamethrin. Although application of adulticides merits use of personal protective equipment (PPE) to limit hazard to handlers, proper uniforms, industrial filtering masks, goggles, and gloves were not observed by the assessment team, thus suggesting that protection measures to reduce insecticide exposure in operators is not appropriately enforced.

There is reason to believe the efficacy of pyrethroid application in El Salvador to control adult mosquitoes may be low, due to existing insecticide resistance. Unfortunately, capacity in country to carry out resistance testing is limited. The only study published on the matter, reported incipient resistance to deltamethrin in the metropolitan area of San Salvador.[18] In addition, multiple reports of permethrin resistance, both biochemical and point mutation, have been reported in neighboring countries.[19] Given the lack of test data on insecticide resistance in El Salvador, it is imperative to determine the resistance status of the local *Aedes aegypti* population as soon as possible.

MINSAL complements the aforementioned control methods with community-driven source reduction via public engagement and mobilization. These efforts focus on increasing community participation in eliminating mosquito breeding sites – discarding unused water-bearing containers and education around proper management of useful receptacles (e.g. washbasins, drums, buckets, etc.). National clean-up campaigns and specific days dedicated to source reduction are planned and implemented on a quarterly basis countrywide because of the current urgency. Anecdotally, these clean-up campaigns have achieved notable results, although no data were made available to confirm their effectiveness.

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[16] https://archive.epa.gov/pesticides/reregistration/web/html/temephos_red.html

[17] Residual effect: mortality in fortnightly standard wall bioassay cones, exposing mosquitoes on treated wall surfaces, for 30 min and 24 h observation period to assess mortality. Residual effect is maintained while mortality remains ≥80%. http://apps.who.int/iris/bitstream/10665/69296/1/WHO_CDS_NTD_WHOPES_GCDPP_2006.3_eng.pdf

[18] Bisset Lazcano, Juan A.; Rodríguez María M.; San Martín José L.; Romero José E.; Montoya Romeo. Evaluación de la resistencia a insecticidas de una cepa de Aedes aegypti de El Salvador (Assessing the insecticide resistance of an *Aedes aegypti* strain in El Salvador). *Rev Panam Salud Publica* 26 (3). Washington, Sep. 2009). http://www.scielosp.org/scielo.php?script=sci_arttext&pid=S1020-49892009000900007

[19] García GP, Flores AE, Fernández-Salas I, Saavedra-Rodríguez K, Reyes-Solis G, Lozano-Fuentes S, Guillermo Bond J, Casas-Martínez M, Ramsey JM, García-Rejón J, Domínguez-Galera M, Ranson H, Hemingway J, Eisen L, Black IV WC. Recent rapid rise of a permethrin knock down resistance allele in *Aedes aegypti* in México. PLoS Negl Trop Dis. 2009;3(10):e531.

3. Findings

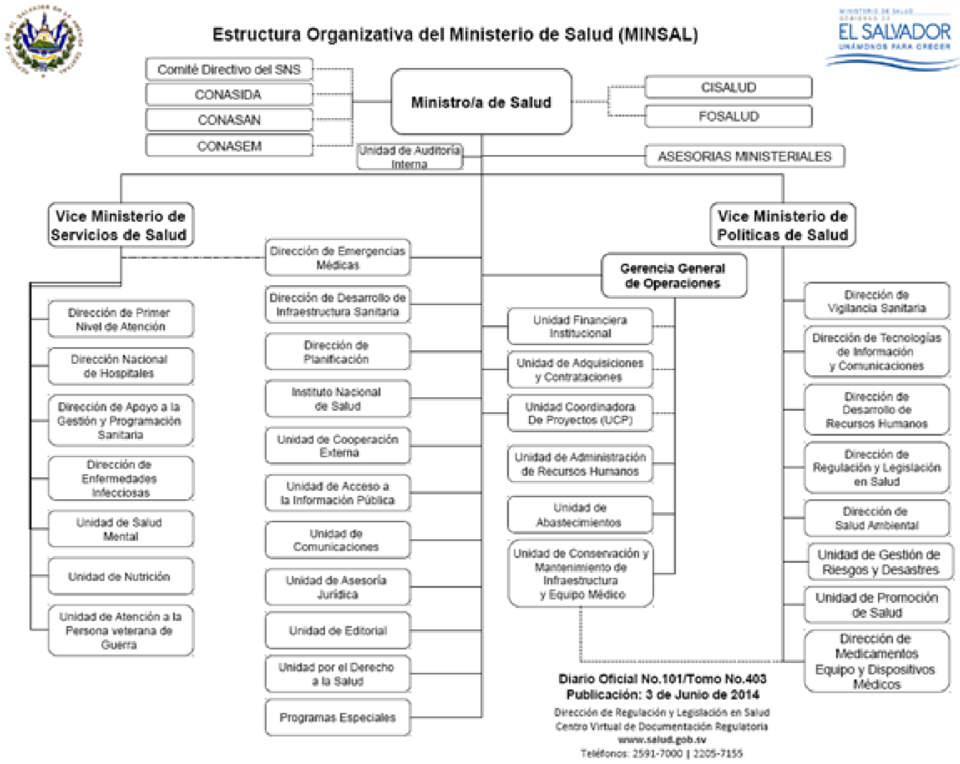
3.1 Place, Structure, and Financial Resources of Entomological Surveillance and Vector Control

3.1.1 National Level

In El Salvador, vector control and surveillance activities fall under the remit of the Vector Control Division and integrated government departments within MINSAL. Vector-borne diseases of concern include malaria (transmitted by anopheline mosquitoes), leishmaniasis (transmitted by phlebotomine sandflies), Chagas disease (transmitted primarily by Triatominae), and a number of arboviral diseases. The arboviral diseases of greatest public health concern in El Salvador are dengue, chikungunya, and Zika; all have the same primary mosquito vector, namely, *Aedes aegypti*. These arboviruses are all notifiable diseases in El Salvador and epidemiological data for the diseases are reported into a central online database. This information is then used to coordinate stakeholder response activities.

The organizational structure of MINSAL is shown in Figure 1. The Vector Control Division operates within an integrated structure with strong links to departments and divisions of MINSAL and to other government departments and NGOs. On the national level, MINSAL and associated vector control activities are divided into five regions known as "Higher-level Vector-borne Disease Surveillance Units." Each of these units covers a number of SIBASI (*Sistema Básico de Salud Integral*) integrated care systems that provide preventive, primary, and hospital care, and smaller regional clinics known as Community Family Health Units. Each unit contains between 10 and 14 Family and Specialized Health Community Teams (ECOS) that are primary health care providers and responsible for day-to-day vector control activities. In El Salvador, there is one ECOS team per approximately 600 families, with each team consisting of a doctor, a nurse, a nursing assistant, three health promoters, and an additional team member with a variety of functions.

FIGURE 1: ORGANIZATIONAL STRUCTURE, MINSAL



At the national level, the Health Surveillance and Environmental Health Directorate oversees epidemiological surveillance, vector control, and vector surveillance activities. Within the directorate, there is a steering committee dedicated to arboviruses, composed of members of the Department of Infectious Diseases, Communications Unit, Promotion Unit, Epidemiology Unit, Vector Control Unit, National Reference Laboratory, National Institute of Health, Salvadoran Social Security Institute, Directorate of the Hospitals Authority Pan American Health Organization (PAHO). The committee meets weekly to review vector control and surveillance activities, including use of the Epidemiological Bulletin, a weekly online summary of all data related to vector control and surveillance activities from 1,234 ECOS units. These data are entered by ECOS teams into a central online database known as the UNICO system (for *Sistema Único de Información*, SUIS), are analyzed at the national level by MINSAL, and disseminated via an Epidemiological Bulletin page of the MINSAL web domain: http://www.salud.gob.sv/tag/boletines-epidemiologicos-2016/.

Data on epidemiological and entomological surveillance are used by the committee to prioritize control activities according to greatest need and estimated impact of potential interventions. Entomological data is based on larval indices calculated from data collected by routine house-to-house larval surveys. The data is reported as the House Index which is the percentage of houses infested with larvae and/or pupae. The data is comprehensive in terms of frequency of collection and area (surveys are conducted countrywide) but the quality of the data is unverified because the assessment team did not directly observe data collection. Guidelines for chemical and other control measures are periodically developed and disseminated by the committee, the first of which was a Zika yellow alert released on March 10, 2016 published by the Salvadoran Government.[20] Disease incidence may also be used for planning and mobilizing local Civil Protection Units (Ministry of Interior) activities against *Aedes* mosquitoes. Civil Protection Units are activated after natural disasters, but when the yellow alert was enacted, they were also appointed to participate in the Zika response program and are in charge of implementing large scale cleaning campaigns nationally every three months to eliminate mosquito breeding sites.

As previously noted, MINSAL's approach to vector management is integrated with chemical, biological, and physical control measures. Chemical control targets both adult and larval vector stages – 1% temephos against larvae and deltamethrin for adult stages applied via IRS or thermal fogging. Biological control measures are carried out at national and local levels using insectivorous fish such as *Tilapia* or *Gambusia*. These measures are facilitated by MINSAL on a limited scale, with funding from external donors (e.g. *Operación Bendición*[21]), working with residents via house-to-house visits or children during routine outreach at schools. Physical control activities, such as source reduction campaigns, are planned by the arbovirus steering committee and organized on specific days for the collection and disposal of large household waste items. These collections are usually carried out during the dry season. In addition, there is a National Dengue Prevention day in August that targets *Aedes aegypti* breeding sites through washing, covering, or inverting useful containers and eliminating containers that serve no tangible purpose. Container collection and clean-up activities are carried out in communities, and at government buildings, employee housing, and schools.

Planning for the Vector Control Division occurs on a yearly basis through the Annual Operational Planning process, with proposals submitted to MINSAL to cover all vector-borne diseases. The budget for the division is not vector-specific, nor does it include a dedicated budget line for vector control aside from purchase of insecticides, which amounted to US$1 million in 2016 for control of all vector-borne diseases in the country. Other materials and supplies required for vector control and surveillance activities are purchased using the general budget for the SIBASI. Financial data related to vector control activities were not made available to the assessment team, for which detailed cost breakdowns by administrative level or vector-borne disease were not ascertained.

Additional funding can be made available by the Civil Protection Unit, who has since February actively participation in the Zika response. Funding, however, for the unit is minimal, with US$5 million for all emergency activities associated with natural disasters and adverse events, including Zika. Officials from the Civil Protection Unit displayed a willingness to engage further in Zika containment efforts, provided additional funds could be made available (Annex C, proposal for funding Civil Protection activities for Zika relief).

3.1.2 Subnational Level

The Vector Control Division is divided into various administration levels – national, regional, departmental, SIBASI, and local – each with their own specific and clearly defined operational plan for entomological surveillance and vector control activities. Every level has a documented Annual Plan that outlines the scope of its responsibilities and activities for the year. At the departmental level, vector control activities are planned, coordinated, and implemented by trained entomologists (32 in total). Vector control and surveillance at the local level is performed by the ECOS.

All *Aedes aegypti* and *Aedes albopictus* surveillance activities carried out by ECOS teams are recorded on the '*Aedes* entomological form 1' and summarized on the '*Aedes* entomological form 2.' Likewise, control activities are recorded on '*Aedes* entomological form 3' and summarized on '*Aedes* entomological form

[20] https://www.salud.gob.sv/archivos/comunicaciones/archivos_comunicados2016/pdf/Boletin_Alerta-Amarilla-proteccion_civil10032016.pdf
[21] https://www.facebook.com/OBIElSalvador

4.' Information from the summary forms is entered weekly into the Vector Module of a centralized online database, UNICO. Community-level data is reviewed at the regional level, after which feedback is provided to ECOS teams.

Entomological surveillance data is collected on a daily basis by ECOS and compiled into summary reports that are submitted once per week through the UNICO system. Data are collected according to specific guidelines and based on a non-randomized sampling regime for selecting houses to be included in the survey. Sites are then inspected for containers harboring larvae. No ovitrap sampling is carried out. If completed according to plan, the entomological surveillance activities are sufficient to inform the planning and implementation of vector control. However as previously stated, the quality of the data collected was not directly assessed. Further details of the non-randomized sampling regime are required to fully assess its usefulness. For example if the same yards are surveyed and treated week after week it is likely that they are no longer representative of the surrounding houses.

3.2 Stakeholders' Coordination and Community Mobilization /Engagement for Control of *Aedes* Mosquitoes

3.2.1 National Level

One of the primary roles of the arbovirus steering committee is to ensure regular communication and coordination among vector control stakeholders. This occurs primarily through the weekly committee meetings, which provide a platform for review of epidemiological and entomological data, and strategic discussions on vector control, community engagement and mobilization, and behavior change communication (BCC).

Community engagement and mobilization is integral to effective vector control in El Salvador. Specific strategies are in place for the national, departmental, SIBASI, community, and Family Health Unit levels to foster greater community involvement in control activities, though these plans were not provided to the assessment teams. The steering committee approves plans on an annual basis, after which they are stored in the Statistical Service Production System (SEPS) database, and maintained by the Unit for Health Promotion and Communications.

To increase community awareness of the various arboviruses transmitted by *Aedes* mosquitoes, MINSAL has produced a range of BCC materials, available on the ministry's website to download and/or print.[22] There is no dedicated budget for the production and dissemination of these materials, nor is additional funding accessible. As a result, stocks have been depleted and the materials are currently unavailable for distribution throughout the country. Television and radio campaigns have been used for similar efforts in the past, but budget restrictions preclude these methods as means of raising community awareness to the threat of Zika.

3.2.2 Subnational Level

At the subnational level, the primary stakeholders are the communities at greatest risk. Some public education on arboviruses is undertaken by ECOS field workers as part of their day-to-day control and surveillance activities. This involves direct, face-to-face discussions with community members and the distribution of BCC materials, when available. ECOS teams are also involved in the organization and training of community action groups. Moreover, anecdotal evidence suggests that community-wide

[22] http://www.salud.gob.sv/documentos/

control efforts are conducted by specific groups, such as churches and schools, under the advice and direction of MINSAL or the Civil Protection Unit of the Ministry of the Interior.

3.3 Human Resources

3.3.1 National Level

There are 32 entomologists in the Vector Control Division of MINSAL with the capacity to identify adults and larvae of the primary and secondary Zika vectors (i.e. *Aedes aegypti* and *Aedes albopictus*) and to plan, implement, and evaluate Zika-related entomological surveillance, vector control, and environmental compliance activities. In addition to the entomologists, there are specialists in geographical information systems (GIS), epidemiologists, public education experts, and medical doctors. Most staff involved in vector control have several years of experience and are capable of developing plans and guidelines for vector control. Similarly, the division collaborated with COMISCA to develop the regional Action Plan for the Prevention and Control of Zika Virus in Central America and Dominican Republic. The regional plan was designed to bring together regional and national level stakeholders in a coordinated response to Zika and other diseases transmitted by *Aedes aegypti*. The plan provides recommendations and suggested actions to address Zika, and includes strengthening national epidemiological surveillance and vector control program, and forming community networks to implement preventive actions in epidemic and inter-epidemic periods.

3.3.2 Subnational Level

At the subnational level, vector surveillance and control activities are carried out by 1,234 notifying units, and include one national-level environmental health inspector per department, department-level health promoters, municipal personnel, and volunteers. There are approximately 4,220 field technicians nationwide. National-level technicians, however, carry out additional activities besides vector surveillance and control, including environmental sanitation and water safety. The assessment team was not able to visit any departmental sites, for which verification of the quality of subnational work was not possible to ascertain.

3.4 Infrastructure

3.4.1 Presence of Reference Laboratory at the National Level

El Salvador does not have an entomological reference laboratory, which hinders the country's ability to conduct a range of activities from basic morphological identification with dichotomous keys to more advanced molecular biological techniques for determination of resistance mechanisms. The most common and routine activity of an entomology reference laboratory is to perform routine resistance testing on all larvicides and adulticides used or planned for future use. The ability to do routine resistance testing is essential for a vector control program, and severely limits the capacity of MINSAL's Vector Control Department to evaluate its control interventions. A solid, functional laboratory could be established at minimal cost.

3.4.2 Functional Insectary

The lack of a functional insectary with trained laboratory technicians is a significant weak point in an otherwise strong vector control program. Such a facility need not be very complex, nor would it require extensive or highly advanced equipment. A basic facility consists of a larval rearing area, a central work area, and an adult holding area, separated from one another due to distinct temperature, humidity, and lighting requirements. A larval rearing area requires a temperature, humidity, and photoperiod controlled room, shelving for trays in which to rear larvae, and powdered animal feed to feed them. For the adult holding area, a temperature, humidity, and photoperiod controlled room is preferred though not essential. Otherwise, the only other requirements are shelving for cages of adult mosquitoes and a laboratory animal (e.g. rabbit, rat, or guinea pig) or membrane feeding apparatus to ensure the mosquitoes are fed. The central working area requires temperature and humidity control and basic laboratory equipment such as binocular microscopes. The unused entomology laboratory in the headquarters of the National Vector Control Program would make a suitable location for an insectary.

As the assessment team did not visit any subnational vector control units, it could not be assessed whether or not there are adequate facilities or locations outside of San Salvador to install an insectary. While it may not be necessary, with a constant electricity source and reliable water supply, most any structure could be outfitted to serve as an insectary.

3.5 Capacity to Design and Prepare Entomological Monitoring, Vector Control, and Environmental Control Plan

3.5.1 National Level

Capacity at MINSAL to design and plan entomological monitoring, vector control, and environmental compliance plans appears strong, even though no written plans were made available to the assessment team. Moreover, health education campaigns are designed and launched by MINSAL, and include elements of entomological monitoring, vector control, and environmental compliance, along with community mobilization. However, additional support is needed to develop a plan for entomological monitoring that includes insecticide resistance monitoring, as such tests have never been carried out by MINSAL staff.

Systems for data recording, analysis, and reporting in El Salvador are highly developed and efficient. The vector control activities reported in the weekly Epidemiological Bulletin include data compiled from neighboring countries and from the region as a whole. The Bulletin also contains maps, derived from data stored in the UNICO system, of distribution of Zika vectors, intensity of Zika transmission, distribution and type of breeding sites, vector control methods employed, and the quantity and type of insecticides in use. Mapping of other insecticide usage, such as for agricultural and household usage, is needed as it would help to explain variations in resistance levels of mosquito vectors. The accuracy and usefulness of all maps created from the source data depend upon data completeness and accuracy, highlighting the need for quality assurance of the data collected.

Entomological monitoring for Zika and other arboviruses is driven at the national level and has been implemented in El Salvador for a number of years. Some 7,000 field workers, including 4,220 technicians and nearly 2,800 health volunteers, conduct weekly monitoring at 1,234 notifying units through sampling of mosquito larvae in houses and application of the *Stegomyia* indices, namely the house infestation index, container index, and Breteau index.[23] Collected data are uploaded into the UNICO system and then used to inform vector control activities. While regular monitoring and uploading of data is notable, there is reason to question the usefulness of the data in assessing entomological risk for arboviral disease transmission. The sampling method used to quantify the presence of mosquito larvae in houses is non-random, thus limiting its utility in accurately informing and pinpointing vector control activities.[24]

[23] Connor ME, Monroe WM. Stegomyia indices and their value in yellow fever control. Am J Trop Med Hyg. 1923;1: 9–19.
[24] Bowman LR, Runge-Ranzinger S, McCall PJ (2014) Assessing the relationship between vector indices and dengue transmission: A Systematic Review of the Evidence. PLoS Negl Trop Dis 8(5): e2848.

Optimizing the effectiveness of vector control is dependent on optimizing the effectiveness of entomological surveillance through improved quality assurance beginning data. Recent developments in mosquito surveillance methodologies, such as surveillance with ovitraps (VEO) used in Mexico, could be a viable alternative in El Salvador.[25] This methodology consists of quota sampling throughout select cities, placing ovitraps in sets of nine city blocks and carrying out weekly collections. Presence of mosquitoes is expressed in eggs per block and divided into quartiles of entomological risk. Home addresses of suspected arbovirus cases can be mapped and then compared with entomological risk levels to build a transmission risk index. The result will be a map with 'hot-spots' around each nine block set which can then be prioritized and treated.[26]

Although the frequency of data collection and uploading into the UNICO system is adequate, there do not appear to be mechanisms in place to monitor and control the quality of data within the system. With no laboratory facilities for mosquito taxonomic determination, this is an area that merits strengthening. Moreover, data from areas with high levels of violence are likely to be of lesser quality, while also being areas with high risk for Zika transmission.

In addition, to better plan use of effective insecticides for vector control operations, it is necessary to periodically (e.g. once or twice per year) monitor insecticide resistance. If resistance data were available, it could easily be included in the UNICO database and used to create current and historical maps on vector resistance to both adulticides and larvicides across the country. Likewise, the current UNICO system could be used to record survey data on community awareness about Zika and its mode of transmission, vector breeding habitat, and general level of health education. This would assist in evaluating the impact of BCC interventions, further informing the development of a comprehensive set of vector control strategies.

3.5.2 Subnational Level

Visits were not made to sites outside of San Salvador, thus hindering an assessment of subnational capacity to design and prepare vector control, entomological monitoring, and environmental compliance activities at the subnational level. However, given the minimal human, material, and financial resources observed at the ECOS visited, it is unlikely that the capacity to carry out appropriate vector surveillance and control activities is strong. At the departmental level, there are 32 trained entomologists for the country. While departments do produce and submit annual operational plans to MINSAL for approval, the level of training and ability to prepare and evaluate vector control/surveillance plans remains unknown. During the assessment visit the lack of continual training was frequently mentioned as being an area for improvement.

3.6 Implementation Capacity

3.6.1 National Level

Aside from the budget amount dedicated for procurement of insecticides, reported at US$1 million for 2016, the Vector Control Division of MINSAL lacks a specified budget for vector surveillance, other vector control activities, and physical necessities such as vehicles, fuel, spray equipment, and uniforms. All funding for these activities is drawn from the overall budget of the SIBASI, which is insufficient for the Vector Control Division to procure the equipment, materials, and reagents needed for

[25] http://www.gob.mx/cms/uploads/attachment/file/37865/guia_vigilancia_entomologica_ovitrampas.pdf
[26] Hernández-Ávila JE, Rodríguez MH, Santos-Luna R, Sánchez-Castañeda V, Román-Pérez S, Ríos-Salgado VH, Salas-Sarmiento JA, Arredondo-Jiménez JI. Nation-wide, web-based,geographic information system for the integrated surveillance and control of dengue fever in Mexico. PLoS One. 2013;8(8):e70231.

entomological monitoring activities. As a result, comprehensive implementation of the division's operational plans routinely comes up short.

The division records a wide range of entomological surveillance measures including the species composition of Zika vectors, their distribution, and their seasonality. All mosquito assessments are undertaken through larval studies of target mosquitoes using *Stegomyia* indices. Quantitative counts of actual mosquito stages (i.e. eggs, pupae, and adults) are not tabulated. The division manager noted that all vector control operations were based on the entomological risk determined through application of these indices, targeting for treatment those areas at higher entomological risk. No data were available for review during the assessment team's visit, though the house infestation rate was stated to be eight percent nation-wide. Such a figure is considered by PAHO as demonstrating a high risk of dengue transmission.[27]

Although these surveillance data are entered into the UNICO system and used to produce weekly activity reports, the validity of the data could not be verified at the time of the assessment. With no quality assurance mechanisms in place for vector control and surveillance activities, validation of these data is difficult. Moreover, lack of quality assurance measures impedes verification of the efficacy of ongoing vector control measures, includes larviciding, thermal fogging, and indoor residual spraying (IRS). The extent, use, and success rate of biological control interventions (i.e., *Tilapia* and *Gambusia* fish), reported as widespread and highly effective, similarly cannot be evaluated due to the lack of available data.

Primarily due to the lack of a reference entomology laboratory and insectary, and associated laboratory personnel, the Vector Control Division has limited capacity with which to carry out operational research activities. These include, but are not limited to, determination of vector resting behavior, infectivity, and parity rates, and investigations into insecticide resistance presence, mechanisms, and distribution. Collection and analysis of data on insecticide and larvicide susceptibility is nonexistent, thus forcing the division to proceed with control activities that may be ineffective. A paper from 2009, for example, suggests resistance among the local *Aedes aegypti* population to the larvicide temphos,[28] which continues to be used widely in the country. Considering the scarcity of published research papers, collaboration with external research organizations also appears minimal.

MINSAL has sufficiently competent staff to produce BCC materials and a large repository of leaflets, pamphlets, and other documents is available on the MINSAL website. Yet budgetary limitations prevent adequate printing and dissemination of these materials; the funds set aside for printing in 2016 ran out in the first three months of the year. Furthermore, there is no strategy in place to assess the effectiveness of these measures and to improve them based on feedback from the target population. As with the efficacy of chemical and biological intervention methods, the extent to which these materials enhance community-based source reduction is unknown.

3.6.2 Subnational Level

The effect of budgetary limitations on the capacity to implement vector control activities is most evident at the departmental level. Vector control operations are challenged by insufficient personnel few vehicles with which to apply insecticides and transport field personnel; ineffective spray equipment (e.g. thermal foggers), a lack of laboratory facilities; and use of insecticides that may be ineffective due to resistance of local vectors.

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27 Pan American Health Organization. Dengue and dengue hemorrhagic fever in the Americas: guidelines for prevention and control. Scientific publication no. 548. Washington: The Organization; 1994.

28 Bisset Lazcano, Juan A.; Rodríguez María M.; San Martín José L.; Romero José E.; Montoya Romeo. Evaluación de la resistencia a insecticidas de una cepa de Aedes aegypti de El Salvador (Assessing the insecticide resistance of an Aedes aegypti strain in El Salvador). *Rev Panam Salud Publica* 26 (3). Washington, Sep. 2009).

Building facilities were seen to be abandoned and in need of basic maintenance. Chemical storage facilities were inadequate and there was a glaring lack of disposal facilities for insecticide residues and contaminated equipment. Moreover, some insecticides were several years out of date. Spray equipment, including truck-mounted ultra-low volume sprayers, thermal foggers, and compression sprayers were in poor state and haphazardly stored. No maintenance records were available for any spray equipment, and workers reported a lack of spare parts to enable their upkeep. It is likely that very little training was provided to employees related to equipment maintenance and calibration.

Vector control activities carried out at the local level include use of temephos (1 ppm) for larviciding, and EW formulations of deltamethrin and permethrin for adulticiding, via portable and truck-mounted thermal fogging equipment, at dosages, respectively of 2 and 10 g AI/Ha. It appears that larviciding is routine whilst adulticiding is carried out in response to disease transmission. These activities are seldom undertaken simultaneously in the same areas, therefore likely failing to take advantage of potentially additive control effects.

The availability of PPE was very limited and what was provided was unsuitable for the purposes for which it was being used. An example of this was the PPE used when applying insecticides using thermal fogging equipment. No protective goggles, gloves, or disposable Tyvec suits were provided or available in facilities. The half facemasks provided were designed for dust protection and not suitable for the application of insecticides.

3.7 Data Collection, Analysis, and Reporting

3.7.1 Capacity to Capture Comprehensive Entomological, Environmental Compliance, and Vector Control Data in One Central Database

Data collection related to entomological monitoring and vector control is carried out by the ECOS teams, who have printed worksheet formats on which to record *Aedes* control and surveillance activities on a daily basis. Data from the worksheets are compiled into weekly reports, input into the UNICO system, and then analyzed at the regional level. However, there is no QA system for data collected.

The online database system has a module dedicated to the collection of entomological data. The modular structure allows for customization, so that data not currently collected in the system could easily be added. Data on resistance testing or molecular laboratory data, for example, could be included, should El Salvador develop the capacity for this type of entomological data collection. The system already records molecular diagnostic data for human disease diagnosis.

3.7.2 Capacity to Analyze and Interpret Data

El Salvador currently has 32 trained entomologists working in the Vector Control Division. The online UNICO database system currently inputs data on a weekly basis from 1,234 reporting institutes within the country to calculate three distinct larval indices: the house infestation index, container index, and Breteau index. Egg, pupal, and adult indices could be automatically calculated using the same database system if the information were collected by the ECOS teams. Although the capacity is present to do this, it is not necessary that all indices be calculated on a routine basis. Egg indices based on ovipot collections would be a useful addition to the data already collected but would necessitate additional staffing to implement. The UNICO database system also holds data, collected on a weekly basis, relating to vector control coverage, percentage of the population protected via vector control, and the number and percentage of community members educated and mobilized to carry out source reduction for vector control.

The lack of an entomological reference laboratory/insectary and the trained staff required to operate them limits the entomological capacity of the Vector Control Division to carry out certain research-oriented projects. Determination of the percentage of mosquitoes of a given species infected with arboviruses would require specialized quantitative Polymerase Chain Reaction (qPCR) equipment and trained laboratory technicians to carry out the analysis. Studies such as determination of, or changes to, resting habits and vector longevity are not typically carried out as part of routine surveillance activities. To undertake such work would require the establishment of a reference entomology laboratory and/or strengthening links with external research institutions.

3.7.3 Capacity to Produce High Quality Reports

The Epidemiological Bulletin produced by MINSAL, using data collected at 1,234 reporting units, is a model for the region and available online to any interested parties. It compiles and summarizes both epidemiological and entomological data for El Salvador and surrounding countries. All vector-borne diseases of interest to El Salvador are reported, with disease incidence disaggregated by department. While the Bulletin should be considered a benchmark against which other health authorities and relevant organizations model their reports, the lack of quality assurance mechanisms in the country makes it impossible to verify the data that underpin the report. This is another example of the need to prioritize QA of data collection.

3.8 Stakeholders' Engagement and Use of Entomological Data to Inform Vector Control

3.8.1 National Level

MINSAL has well-structured and effective mechanisms in place to ensure robust communication between all stakeholders involved in vector control and surveillance. Central to stakeholder communication is the MINSAL website, http://www.salud.gob.sv/, which offers visitors a wide range of health topics and educational resources. In addition to new bulletins on Zika and other areas of health concern, there is a document repository where the weekly Epidemiological Bulletins are freely available for public consumption.

The Epidemiological Bulletin report details the weekly incidence of all arboviruses affecting El Salvador and neighboring countries. It includes data on the number of pregnant women in the country with suspected or confirmed Zika infection, and the number and departmental distribution of suspected and confirmed Zika cases and Zika-associated Guillain-Barré Syndrome. The Bulletin includes pertinent entomological data for each department including larval indices, number of containers found harboring insectivorous fish, total number of breeding sites found, and type of breeding sites identified. The coverage of vector control activities is reported in terms of total number of houses visited, the percentage of the population covered by control activities, and the total houses treated with larvicides and by thermal fogging. Community engagement activities are recorded in terms of the number of houses visited, hours spent directly interacting with residents, and the total number of pamphlets distributed. The cost of carrying out vector surveillance and control activities is recorded in terms of both human resources involved and quantity of chemicals applied.

Data compiled in the weekly Epidemiological Bulletin are used by the arboviral steering committee to coordinate vector control activities at the national level. This includes identifying disease hotspots, assessing effectiveness of control activities, and determining actions to address deficiencies. The information on planned responses is then fed back to primary health care providers and ECOS units at the district level.

One weakness in stakeholder engagement appears to be limited linkages with national universities and other research institutions. A search of the literature relating to operational research publications in El Salvador returned few results. The National Institute of Health is carrying out some studies and has useful ideas for future research, but lack resources even for publication. Collaborations with external research facilities would assist with making progress toward answering research questions related to critical topics such as resistance mechanisms and evaluation of control interventions.

3.8.2 Subnational Level

Vector control and management activities are first planned annually at the regional level by ECOS, and then submitted to MINSAL and the arboviral steering committee for review and approval. This ensures that all stakeholders are involved at an early stage in the planning and development of vector control activities. The ECOS teams constitute the front line of vector control activities and are directly involved in the dissemination of Information, education, and communication (IEC) and BCC materials and verbal communication of information to residents. They are also responsible for the implementation of activities mandated by the national level, including community mobilization days in which community members assist with the removal of potential breeding sites.

3.9 Insecticide Registration Status and Environmental Compliance

3.9.1 National Level

In September 2013, the Congress of El Salvador proposed regulations to prohibit the use of 53 pesticides.[29] This bill, however, was not enacted, as the president of El Salvador demanded evidence on why 11 products not forbidden in other countries were suggested for withdrawal from use in the country.[30] As the decree has yet to be enacted, there are no pesticides that are formally forbidden from use.

The main pesticide storage facility for the country, located in San Salvador, lacks basic elements critical to storing and maintaining chemical and biological products, as well as equipment to guarantee the safety of facility staff. The storage area was not air-conditioned, limiting the potential for warehousing of biological insecticides such as Bti or Spinosad. There was no forklift to lift pallets of insecticides, and many of the chemicals on site were expired. Chemical response and containment equipment were unavailable, as were respirators, goggles and gloves.

3.9.2 Subnational Level

At the subnational level, local officials have no control on which insecticides are to be used, as MINSAL officials at the national level determine which products are to be used in country. At a visit to an ECOS unit, the storage facilities for insecticide were found to be substandard. The facility was without a wall on one side, the roof was leaking, and it was in a general state of disarray. There were no chemical items stored at the location during the time of visit. A large pile of empty, discarded insecticide bottles was adjacent to the storage area. The assessment team could not determine whether the absence of containers with insecticide was due to the poor condition of the facility or if the containers were at a distance from the ECOS headquarters, which only serves to store empty containers.

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[29] Asamblea Legislativa de El Salvador. Propuesta de Decreto 473. Reformas a la Ley sobre control de plaguicidas, fertilizantes y productos para uso agropecuario. 5/09/13.
[30] Oficio enviado por el Presidente Mauricio Funes. Observaciones al Decreto 473. 1/10/13.

4. KEY ISSUES AND CHALLENGES

1. **Insufficient funding for management of Zika-transmitting vectors.** With the exception of the budget amount dedicated for procurement of insecticides, reported at US$1 million for 2016, the Vector Control Division of MINSAL lacks a budget for vector surveillance, other vector control activities, and physical necessities such as vehicles, fuel, spray equipment, and uniforms. All funding for these activities is drawn from the overall budget of the SIBASI, which is insufficient for the Vector Control Division to procure the equipment, materials, and reagents needed for entomological monitoring activities. As a result, comprehensive implementation of the division's operational plans routinely comes up short. In theory, additional funding can be made available through the Civil Protection Unit, yet funding for the unit stands at around US$5 million yearly for all emergency activities associated with natural disasters and adverse events, including Zika.
2. **Limited capacity for QA and entomological studies.** A key issue limiting the capacity of El Salvador to respond to arboviral vectors is the lack of a QA system for surveillance data and a reference entomology laboratory and associated insectary facilities. As a result, the accuracy and completeness of all source data is unclear. Routine resistance testing of both larvicides and adulticides is not possible, nor is the monitoring and evaluation of chemical-based intervention methods. El Salvador cannot investigate the effectiveness of new chemical products, review resistance mechanisms in its *Aedes* populations, or carry out fundamental research studies into the behavior and ecology of mosquitoes. Given the minimal investment, in terms of cost to provide basic laboratory and insectary facilities, this situation can easily be addressed.
3. **Potential resistance to insecticide in use among Zika vectors.** While the current status of pyrethroids used for routine control activities remains unknown, it is likely that *Aedes aegypti* exhibits a high degree of resistance to these chemicals. In El Salvador, *Aedes aegypti* has been shown to be resistant to temephos, yet it is still in use probably a result of its relatively low cost. National registration of unlisted products could be fast-tracked if effective insecticides are advised. It is, however, not overtly clear which alternative larvicides and adulticides are registered for use in El Salvador. Development of an insecticide resistance management plan would allow for the establishment of strategies to limit future resistance, such as through rotations of insecticide in use.
4. **Over-reliance on vector control methods that are likely ineffective.** The primary method for applying adulticides in El Salvador appears to be via thermal fogging. While thermal fogging is effective at killing adult mosquitoes, it provides no residual effect and is essentially a short-impact intervention method. IRS using compression spray or mist-blower equipment would likely provide a much longer-lasting residual effect,[31,32,33] and given the indoor resting behavior of *Aedes aegypti,*[34]

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[31] Chadee DD. Resting behaviour of Aedes aegypti in Trinidad: with evidence for the re-introduction of indoor residual spraying (IRS) for dengue control. Parasit Vectors. 2013;6(1):255.
[32] Villarreal C, Rodriguez MH, Bown DN, Arredondo-Jiménez JI. Low-volume application by mist-blower compared with conventional compression sprayer treatment of houses with residual pyrethroid to control the malaria vector *Anopheles albimanus* in Mexico. Med Vet Entomol. 1995;9(2):187-194..
[33] Arredondo-Jiménez JI, Rodríguez MH, Bown DN, Loyola EG. Indoor low-volume insecticide spray for the control of *Anopheles albimanus* in southern Mexico. Village-scale trials of bendiocarb, deltamethrin and cyfluthrin. J Am Mosq Control Assoc. 1993;9(2):210-20
[34] Chadee DD. Resting behaviour of *Aedes aegypti* in Trinidad: with evidence for the re-introduction of indoor residual spraying (IRS) for dengue control. Parasit Vectors. 2013;6(1):255.

it is expected that it could be more effectively controlled by IRS adapted for urban environments than by thermal fogging, which only provides ephemeral control.[35]

5. **Substandard practices related to insecticide and equipment management.** Chemical storage facilities in El Salvador are for the most part inadequate, and lack basic elements critical to storing and maintaining chemical and biological products, as well as equipment to guarantee the safety of facility staff. Some storage areas are not air-conditioned, thus complicating the warehousing of biological insecticides such as Bti or Spinosad. Facilities and protocols for storage and disposal of insecticide residues and contaminated equipment are largely unavailable. Moreover, there is evidence of insecticides remaining in stock that are several years out of date. Spray equipment, including truck-mounted sprayers, thermal foggers, and compression sprayers were in poor state and haphazardly stored. Chemical response and containment equipment were unavailable, as were respirators, goggles and gloves. Not only is the availability of PPE limited, it is often unsuitable for the purposes for which it was being used. Until a clear plan is in place for the handling, transport, use, and disposal of insecticides, worker safety will be at risk.

[35] http://apps.who.int/iris/bitstream/10665/68057/1/WHO_CDS_WHOPES_GCDPP_2003.5.pdf

5. RECOMMENDATIONS

5.1 Recommendations to the Government of El Salvador

1. **Ensure that sufficient funding is dedicated for management of Zika-transmitting mosquitoes.** Comprehensive vector control in El Salvador requires more funds than are currently allotted. Line item budgets should detail procurement of insecticides, equipment, and safety supplies such as PPE. Additional funding should be made available for the dissemination of BCC materials to promote improved personal protection from mosquitoes as well as source reduction and environmental management.

2. **Establish a national-level insectary and insecticide testing facility.** The lack of an insectary and corresponding entomological reference laboratory present a significant weak point in an otherwise strong vector control program. A functional insectary would not require extensive or highly advanced equipment, nor would it merit new construction – two rooms with temperature and humidity control and Binocular microscopes would be sufficient. Similarly, a reference laboratory could be established at minimal cost, allowing El Salvador to conduct a range of activities, from basic morphological identification to more complex techniques such as determination of resistance mechanisms.

3. **Determine the resistance status of the local *Aedes aegypti* population.** A report on insecticide resistance of local vector populations in El Salvador noted an incipient resistance to deltamethrin. Neighboring countries have reported high levels of resistance to permethrin in the same vectors. In order to maximize the effectiveness of vector management activities, the generation of data on resistance status remains an imperative. This would include a review of insecticides currently in use as well as those that could be used in the future.

   Based on the reported resistance of local vectors to temephos, the use of alternative larvicides should be explored and targeted for registration for use in El Salvador. Spinosad and pyriproxyfen are two options that are recommended by WHO and U.S. EPA, suitable for application in drinking water, and known to have a sustained residual effect.

4. **Design and implement an insecticide resistance management plan.** Results from resistance studies should be used to design an insecticide resistance management plan that includes mitigation approaches such as rotations of insecticides belonging to different chemical classes. Among these, chlorpyrifos or malathion could be used as an immediate replacement for pyrethroids; however, malathion was recently listed as 2A carcinogen so would merit additional consideration.[36] A module on resistance testing could also be included in the existing online database.

5. **Employ alternative methods for vector management.** Given the suspect efficacy of thermal fogging, alternative control methods should be determined, tested, and eventually put into use to reduce arboviral vector populations. Viable options include IRS adapted for urban environments using compression sprayers[37] and outdoor perifocal treatments. If fogging is to be continued, current equipment in use should be substituted for portable mist-blowers and truck-mounted cold fogging machines. On a related note, the composition of ECOS teams should be reformulated to

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36 https://www.iarc.fr/en/media-centre/iarcnews/pdf/MonographVolume112.pdf.

37 http://www.cenaprece.salud.gob.mx/programas/interior/vectores/descargas/pdf/guia_rociado_residual_intradomiciliar.pdf

have dedicated vector control personnel; those with vector control tasks currently serve various functions.

6. **Develop an environmentally compliant insecticide management strategy and refurbish the main pesticide facility in San Salvador.** Current storage facilities in El Salvador, including the country's primary facility in San Salvador, are inadequate, with protocols needed for proper handling, transport, use, and disposal of insecticides. The government should prioritize the development of an insecticide management strategy that aligns with internationally accepted guidelines, and establishes management procedures to protect the safety of individuals that may be exposed to such products.
7. **Implement a countrywide system for quality assurance of all vector control operations and surveillance data collection.** A QA system for surveillance data is critical to all the preceding recommendations. The QA system would entail routine visits by senior entomologists to all vector control units within El Salvador to accurately determine the capability of these units. This system would identify deficiencies in human resources and equipment and work towards ensuring that all data collected within the country conformed to similar standards and quality. This system would ensure that recommendations were implemented and also enable continual improvement.

5.2 Recommendations to Donors

Donor assistance would ideally be focused on long-term improvements to strengthen the capacity of El Salvador to carry out effective control and surveillance activities against arboviral vectors, primarily *Aedes aegypti*. The following actions are recommended:

1. **Provide funding for technical and professional training in medical entomology.** Long-term sustainability of vector control efforts in El Salvador are contingent on strengthening the capacity of the current vector management workforce and building the workforce of the future. Donors could support an on-site training program in medical entomology that includes mosquito rearing and testing, surveillance and control operations, environmental compliance, and IEC-BCC. Specialized trainers could also provide targeted support on-site for some topics. Others could be covered through a more cost-effective alternative such as the development of a virtual platform. PAHO's platform (https://www.campusvirtualsp.org/en) is a viable option, thereby connecting those involved in similar activities throughout the region.
2. **Consider provision of financial support for an entomology laboratory and separate insectary.** The Government of El Salvador should provide suitable building space for the two facilities and staff to care for mosquito populations and conduct resistance testing. Donor funding could then be used to provide essential equipment and material, as well as periodic support as needed to ensure proper functioning. Donors could also support capacity-building efforts, for new staff to properly maintain mosquito colonies and carry out basic laboratory procedures.
3. **Support strengthening of quality assurance (QA) mechanisms.** Vector control activities are well-planned and the quality of data analysis and reporting is excellent, as are internal feedback mechanisms coordinated by the arboviruses steering committee. The main weakness identified in the vector program is a lack of QA mechanisms for data collection, and to ensure the effectiveness of vector control and surveillance operations. Donors should consider supporting a Vector Control QA Officer whose role is to support the implementation of a QA system for data collection, identify weaknesses in national- and subnational-level vector management efforts, and provide targeted on-site troubleshooting support. The individual could also serve as a technical liaison to MINSAL, providing continuous feedback on the program's progress and highlighting areas in need of more systemic support.

Although there are new vector control innovations available for the control of *Aedes aegypti*, the implementation of these techniques, still unproven, is not currently recommended as a response to Zika transmission. However, if funds are made available for use in operational research projects, the following techniques may prove beneficial:

- ***Oxitec genetically modified mosquito.*** The Oxitec mosquito has reported rates of reduction of *Aedes aegypti* population of greater than 96 percent. WHO has recommended the technique for field testing by independent research groups. Disadvantages include its potential expense and the controversial nature of genetically modified organisms. The main concern is criticism of USAID for carrying out trials of a technique not yet approved or utilized in the United States.
- ***In2Care auto dissemination trap.*** This technique is based on the principle of using adult mosquitoes to carry larvicides to containers harboring larvae thus acting as the disseminators of the larvicides. Theoretically, this is a good idea but as yet it has not been shown to have any impact on mosquito abundance.
- ***Wolbachia-infected mosquitoes:*** The effectiveness of this method is based on the principle that *Aedes aegypti*-infected with *Wolbachia* bacteria cannot transmit dengue or other arboviruses. The technique is free but involves the release of a large number of female (biting) mosquitoes. Trials are currently being planned in the Caribbean. Concerns have been raised about the technique as once the mosquitoes have been released they will breed and cannot be contained. Also at high doses of dengue virus the mosquito will transmit; there are concerns that the release of the mosquito may select for highly viremic strains of arbovirus.
- ***Aerial spraying:*** Aircraft have been used for widespread aerial application of adulticides and or larvicides. This has shown to be effective by a number of control organizations in the United States, Cayman Islands, and Mexico. The viability of the technique in El Salvador is unknown and may not work due to the probable endophilic behavior of the mosquito vector in El Salvador.

ANNEX A: CAPACITY ASSESSMENT TOOL

HFG Project

TOOL TO ASSESS ENTOMOLOGICAL MONITORING, ENVIRONMENTAL COMPLIANCE, AND VECTOR CONTROL CAPACITY

FOR THE PREVENTION AND CONTROL OF ZIKA AND OTHER ARBOVIRUSES

The Health Finance and Governance Project

USAID's Health Finance and Governance (HFG) project helps to improve health in developing countries by expanding people's access to health care. Led by Abt Associates, the project team works with partner countries to increase their domestic resources for health, manage those precious resources more effectively, and make wise purchasing decisions. The five-year, $209 million global project is intended to increase the use of both primary and priority health services, including HIV/AIDS, tuberculosis, malaria, and reproductive health services. Designed to fundamentally strengthen health systems, HFG supports countries as they navigate the economic transitions needed to achieve universal health care.

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Avenir Health | Broad Branch Associates | Development Alternatives Inc. (DAI) |
| Johns Hopkins Bloomberg School of Public Health (JHSPH) | Results for Development Institute (R4D)
| RTI International | Training Resources Group, Inc. (TRG)

TOOL TO ASSESS ENTOMOLOGICAL MONITORING, ENVIRONMENTAL COMPLIANCE, AND VECTOR CONTROL CAPACITY

FOR THE PREVENTION AND CONTROL OF ZIKA AND OTHER ARBOVIRUSES

1. INTRODUCTION

This assessment tool was designed to assess country capacity to conduct *Aedes* vector control and entomological monitoring activities in five countries in Latin America and the Caribbean – the Dominican Republic, El Salvador, Guatemala, Haiti, and Honduras. The purpose of the tool is to review capacity strengths and gaps within each of these countries, and to propose recommendations that improve country readiness to prevent and control Zika and other arboviruses. The tool will assess capacity in line with nine thematic areas:

1. Place, Structure, and Financial Resources of Entomological Surveillance and Vector Control at Various Administrative Levels
2. Stakeholders' Coordination and Community Mobilization /Engagement for Control of *Aedes* Mosquitoes
3. Human Resources
    3.1. National Level
    3.2. Province/District Level
4. Infrastructure
    4.1. Presence of Reference Laboratory at the National Level
    4.2. Functional Insectary
5. Capacity to Design and Prepare Entomological Monitoring, Vector Control, and Environmental Control Plan
6. Implementation Capacity
7. Data Collection, Analysis, and Reporting
    7.1. Capacity to Capture Comprehensive Entomological, Environmental Compliance and Vector Control Data in One Central Database
    7.2. Capacity to Analyze and Interpret Data
    7.3. Capacity to Produce High Quality Reports
8. Stakeholders' Engagement and Use of Entomological Data to Inform Vector Control
9. Insecticide Registration Status and Environmental Compliance

2. Assessment Checklist

Thematic Area	Current Status As applicable: Specify administrative level (e.g. National, Provincial, District, etc.)	Recommendations As applicable: Specify audience (e.g. Government, Donors, etc.)
1. Place, Structure, and Financial Resources of Entomological Surveillance and Vector Control at Various Administrative Levels		
• How are entomological monitoring and *Aedes* mosquitoes of arboviral vector control programs organized structurally? Is it a vertical program or is it integrated into the health offices at various administrative levels? Is entomological surveillance part of vector control? Please attach the copy of the current organogram, if available, to indicate how it relates to other health programs.		
• Are the entomological monitoring and vector control unit/s responsible for all vector-borne diseases? Do these units structurally exist at different levels of administration? If there is no separate unit at a lower administrative level, are there at least focal persons at each administrative level, particularly for the control of *Aedes* mosquitoes that are vectors of arboviral diseases? Describe how the different levels undertake planning, implementation and monitoring and evaluation. Describe the information (report) and feedback flow between the centers and peripheral administrative levels.		
• How are entomological surveillance and vector control for different vector- borne diseases organized? Are they organized under one unit or in different departments? Describe how the entomological surveillance and vector control efforts for different vector-borne diseases undertake joint planning for budgeting, implementation, and monitoring and evaluation, with emphasis on the control of *Aedes* mosquitoes that are vectors of arboviral diseases.		

Thematic Area	Current Status As applicable: Specify administrative level (e.g. National, Provincial, District, etc.)	Recommendations As applicable: Specify audience (e.g. Government, Donors, etc.)
• Do entomological surveillance and vector control efforts for different vector–borne diseases share a common budget at different levels? Which levels are these?		
• Is a there strategic plan for entomological surveillance and vector control for all vector- borne diseases? If yes, provide the copy and briefly describe the different elements of the plan.		
• What is the main vector control methods used to reduce diseases transmitted by *Aedes* mosquitoes? Briefly describe how each of the vector control methods is planned, implemented, monitored and evaluated, and who is responsible at each administrative level for these activities? What indicators are used for monitoring and evaluation? Is the country vector control program open to evaluate and deploy new novel *Aedes* mosquitoes control techniques, if found effective, such as male SIT, Pyriproxyfen, Bti, infection refractory mosquitoes (Wolbachia), and lethal ovitraps, etc.?		
• How frequently is entomological surveillance monitoring data collected? Is it adequate to inform vector control program? Which entomological indicators are regularly monitored? What sampling methods are used?		
• Is there an annual government allocation of funds for entomological surveillance and vector control planning, implementation, and monitoring and evaluation, for the different vector-borne diseases? Please provide a detailed cost breakdown by administrative level and vector–borne disease, if possible. Indicate other sources of funding if any, and short falls in funding level.		
• What is the status and trend of vector resistance to different insecticides and larvicides?		

Thematic Area	Current Status As applicable: Specify administrative level (e.g. National, Provincial, District, etc.)	Recommendations As applicable: Specify audience (e.g. Government, Donors, etc.)
• Is there a central database for entomological surveillance and vector control to which all in country stakeholders have access? Is the country using mHealth for rapid transmission of data from the peripheral to the central database? Is there capacity at the national level to perform appropriate statistical analysis using rigorous statistical methods to inform the vector control program?		
• Does the program have nationwide data on VC coverage in terms number households/people and/ or administrative units like number of municipalities? If yes, please provide the copy of the report. Please disaggregate the data by vector control type if possible.		
• Is there coordination among health care providers (Zika should be the immediately notifiable disease), public health offices, environmental compliance officers, and vector control officers, in terms of sharing of epidemiological, entomological and vector control data? If yes, please describe the information sharing mechanism in place and frequency.		
2. Stakeholders' Coordination and Community Mobilization/ Engagement for Control of *Aedes* Mosquitoes		
• Is there a vector control technical working group or steering committee at the national level? If yes, describe the terms of reference of this committee, the composition of the members and the roles and responsibilities of each member. Please also describe the role and achievement of the steering committee in terms of advancing entomological surveillance and vector control.		
• Are there strategies for social mobilization and advocacy? If yes, please describe how the overall goal of such strategic effort is being achieved.		

Thematic Area	**Current Status** **As applicable: Specify administrative level (e.g. National, Provincial, District, etc.)**	**Recommendations** **As applicable: Specify audience (e.g. Government, Donors, etc.)**
• Are there IEC/ BCC materials available that could help to advance community awareness and knowledge about vector- borne diseases transmitted by *Aedes* mosquitoes? What is best approach to reach out to the community to create awareness?		
• Is there community wide/level surveillance and control of *Aedes* mosquitoes lead by the communities or peripheral health workers? What are the best methods/ approaches to strengthen these activities?		
• Are there systems in place for planning, implementation, and monitoring and evaluation, of IEC/BCC campaigns and community engagement? Is there coordination among the vector–borne diseases control stakeholders in the planning and implementation of IEC/BCC?		
3. Human Resources		
3.1 National Level - Presence of well trained and experienced entomologists, vector control officers, and environmental health officers at the national level that have the capacity to:		
• Develop Zika and other arboviral vector control strategy and guidelines		
• Develop national level entomological surveillance, Zika and other arboviral vector control, and human and environmental safety plans		
• Lead and oversee implementation of entomological surveillance, vector control, and environmental compliance activities		
• Conduct (annual) susceptibility tests on both larvae and adult *Aedes* mosquitoes		
• Determine the competence of suspected *Aedes* mosquitoes in transmission of Zika		

Thematic Area	Current Status As applicable: Specify administrative level (e.g. National, Provincial, District, etc.)	Recommendations As applicable: Specify audience (e.g. Government, Donors, etc.)
• Morphologically identify primary and secondary vectors of Zika		
• Conduct (annual) molecular analysis		
• Conduct biochemical tests if vector resistance to insecticides is detected		
• Manage insectary and sustain susceptible colony of mosquitoes		
• Provide continuous training to sustain pool of trained technicians/ vector control and environmental health officers for entomological surveillance, vector control, and environmental compliance at provincial and district levels.		
• Ensure that high quality entomological data are collected from representative Zika risk areas		
• Map out high transmission risk geographical areas from moderate to low risk (stratification based on the level of risk)		
• Establish one central database that captures entomological surveillance and vector control data at the national level to which all in country stakeholders have access to. Ability to use rigorous statistical methods to analyze data.		
• Immediately share data on insecticide and larvicide resistance, when it becomes available, with in country vector control stakeholders		
• If change in vector density or behavior is observed, share data immediately with in country Zika and Arboviruses vector control stakeholders for decision making		
• Analyze and interpret comprehensive entomological data and share the report with in country Zika and other Arbovirus vector control stakeholders (twice per year)		
• Establish entomological thresholds at which humans get infected with Zika		

Thematic Area	Current Status As applicable: Specify administrative level (e.g. National, Provincial, District, etc.)	Recommendations As applicable: Specify audience (e.g. Government, Donors, etc.)
• Triangulate entomological, vector control and epidemiological data to inform control of Zika and other arboviruses and share this report with in country stake holders (annually)		
• Establish strong intersectoral collaboration among public sectors such as ministry of health, ministry of education, ministry of finance, municipalities, ministry of water resources, etc., private sectors and civil society		
• Develop standard IEC/BCC materials for community mobilization and education campaigns		
• Ensure constant coordination among health care providers (Zika should be an immediately notifiable disease), public health offices, and environmental compliance and vector control officers.		
• Monitor the effectiveness of vector control methods deployed and compliance to human and environmental safety		
3.2 Province/District Level - Presence of trained entomologists, vector control and environmental health officers / technicians working for Ministry of Health or other health institutions that have the capacity to:		
• Establish community- wide survey of aquatic stages (larvae and pupae) of known or suspected vectors of Zika		
• Identify *Aedes* larvae from others (*Culex*, *Anopheles*, etc.)		
• Identify types of breeding containers and geographical areas that are most productive for targeting vector control		
• Develop detailed maps to help track larval sites of Zika vectors		
• Collect *Aedes* mosquito larvae and pupae, and transport and rear them to adults in the insectary for correct identification of species, density monitoring by species, and perform susceptibility tests		

Thematic Area	Current Status As applicable: Specify administrative level (e.g. National, Provincial, District, etc.)	Recommendations As applicable: Specify audience (e.g. Government, Donors, etc.)
• Identify and use proper adult *Aedes* mosquito sampling methods		
• Morphologically identify adult *Aedes* mosquitoes from others (*Culex, Anopheles*, etc.)		
• Morphologically identify male from female *Aedes* mosquitoes		
• Morphologically identify species of *Aedes* mosquitoes		
• Determine vector resting		
• Monitor vector density by species		
• Monitor changes in seasonality and vector composition		
• Monitor changes in vector behaviors		
• Dissection of ovaries and determination of parity rates		
• Properly preserve mosquitoes and send them to the central level for further molecular analysis that includes proper labelling of samples (unique codes corresponding to the sample record, etc.)		
• Assess changes in vector abundance before and after deployment of an intervention (impact of vector control intervention on vector density and behavior)		
• Perform descriptive analysis of entomological data and assess the impact of vector control on entomological indicators		
• Perform resistance testing		
• Perform quality check on vector control products/tools		
• Ensure constant coordination among health care providers (Zika should be immediately notifiable disease), public health offices, environmental compliance officers and vector control officers		
• Conduct community mobilization focusing on reducing or eliminating vector larval habitats		
• Lead community wide source reduction (remove and dispose of water holding containers)		

Thematic Area	Current Status As applicable: Specify administrative level (e.g. National, Provincial, District, etc.)	Recommendations As applicable: Specify audience (e.g. Government, Donors, etc.)
• Make sure that large water holding containers are covered, dumped, modified so that they would not serve as breeding site for the vector or treat the breeding sites with long-lasting larvicide		
• Deploy larvicides (chemical and biological larvicides) where needed		
• Assess the possibility of using biological control (copepods and larvivorious fish, etc.)		
• Deploy adulticides (space spray, residual spray, barrier spray) where necessary		
• Deploy physical control (e.g., non-insecticidal mosquito traps) where feasible		
• Is there funding to support entomological surveillance and control of *Aedes* mosquitoes that transmit arboviruses? If yes, please describe the amount by the source of funding if possible (government, bilateral donors, WHO, etc.).		
4. Infrastructure		
4.1 Presence of Reference Laboratory at the National Level that has the capacity to:		
• Accurately identify Aedes mosquitoes by species using morphological identification key (serve as quality control of field identification work)		
• Accurately label, preserve, and store mosquito samples		
• Labels have unique codes and correspond to some record		
• Do PCR to determine arbovirus infection rates		
• Do molecular analysis to determine mechanism of resistance (KDR and ACE-1R)		
• Conduct biochemical analysis (to identify the presence of detoxifying enzymes) or have connection with other laboratories that have the capacity to perform this activity		

Thematic Area	Current Status As applicable: Specify administrative level (e.g. National, Provincial, District, etc.)	Recommendations As applicable: Specify audience (e.g. Government, Donors, etc.)
• Procure all the equipment, materials, regents and other supplies needed to perform their duties		
• Provide feedback to the field entomologists on the quality of preserved samples received and guidance on how to improve the quality further if needed.		
4.2 Functional Insectary – Presence of one or more functional insectary that has:		
• Separate well-screened adult and larval room with optimal temperature and humidity		
• Consistent water supply		
• Consistent power supply to keep the micro-climate at optimum for rearing mosquitoes		
• Insectary has:		
• Thermometer		
• Hygrometer		
• Heater		
• Humidifier		
• Regular supply of larval food and sugar/blood source for adults		
• Susceptible mosquito colony for vector control and susceptibility test quality control		
• Trained technicians to perform routine activities to sustain mosquito colony		
• Space and capacity to rear field collected larvae and pupae to adult when needed		
• Ability to increase vector population when large numbers of mosquitoes are needed for different activities		

Thematic Area	Current Status As applicable: Specify administrative level (e.g. National, Provincial, District, etc.)	Recommendations As applicable: Specify audience (e.g. Government, Donors, etc.)
5. Capacity to Design and Prepare Entomological Monitoring , Vector Control, and Environmental Plan – Ability to perform:		
• Desk review and compilation of comprehensive entomological and vector control data available including information from neighboring countries		
• Stratification of country using combination of factors that include but not limited to:		
• Distribution of Zika vectors		
• Intensity of Zika transmission		
• Level of community awareness about Zika, its mode of transmission, vector breeding habitat and level of health education needed		
• Distribution and type of breeding sites		
• Type of vector control method used		
• Quantity of insecticides used for agriculture and other vector control purposes		
• History, status and trends of vector resistance to different insecticides and larvicides		
• Uses of insecticides at the house-hold level		
• Based on the assessment results, prepare a comprehensive health education campaign, community mobilization, entomological monitoring, and a vector control and environmental compliance plan		
6. Implementation Capacity - Assess capacity to:		
• Procure equipment, materials, and reagents needed for entomological monitoring activities, vector control, and environmental compliance		
• Entomological monitoring, vector control, and environmental teams have:		
• Transportation services needed for the field work		

Thematic Area	Current Status As applicable: Specify administrative level (e.g. National, Provincial, District, etc.)	Recommendations As applicable: Specify audience (e.g. Government, Donors, etc.)
• Fuel for vehicles		
• Adequate field staff		
• Maintain and calibrate equipment		
• Establish adequate number of sentinel sites in each geographical areas with different levels of disease (Zika) risk and regularly collect data on:		
• Proportion of breeding sites that are positive for aquatic stages of target mosquitoes (eggs, larvae, and pupae)		
• Species composition of the vectors		
• Vector distribution and seasonality		
• Vector resting behavior		
• Vector infectivity		
• Parity rates		
• Collect data on insecticide and larvicide susceptibility and mechanism of resistance from Zika infested areas annually		
• Conduct community education and mobilization campaign at the community level to promote source reduction (environmental management), weekly		
• Monitor environmental management (source reduction) activities by the community and coverage, weekly		
• Perform IRS, mosquito traps where effective, and assess the feasibility of biological control		
• Apply larvicides on breeding sites that can't be removed by source reduction or covered to prevent mosquito breeding on a weekly interval?		

Thematic Area	Current Status As applicable: Specify administrative level (e.g. National, Provincial, District, etc.)	Recommendations As applicable: Specify audience (e.g. Government, Donors, etc.)
7. Data Collection, Analysis, and Reporting		
7.1 Capacity to Capture Comprehensive Entomological, Environmental Compliance and Vector Control Data in One Central Database		
• Have standard data collection tools /worksheets for entomological monitoring, IEC/BCC, vector control, and environmental compliance across the country		
• Presence of central entomological, vector control, and environmental compliance databases		
• Ability to link molecular/lab data back to field specimens		
7.2 Capacity to Analyze and Interpret Data - Capacity to perform some descriptive analysis and interpret and determine entomological indices:		
• Determine larval, pupal, egg, and female adult survey indices		
• Proportion of mosquitoes of a given species infected with arboviruses		
• Resting habit		
• Longevity of the population of vectors		
• Interpret the entomological measurements and their implication on vector control and local epidemiology of Zika.		
• Number and percentage of community educated and mobilized for vector control		
• Vector control coverage		
• Number and percentage of population protected by vector control		
7.3 Capacity to Produce Good Quality Report		
• Produce good quality progress and final report that can be shared with stakeholders		

Thematic Area	Current Status As applicable: Specify administrative level (e.g. National, Provincial, District, etc.)	Recommendations As applicable: Specify audience (e.g. Government, Donors, etc.)
8. Stakeholders' Engagement and Use of Entomological Data to Inform Vector Control		
• The presence of functional inter-sectoral coordination mechanism established in the country		
• Organizational structure of MOH established to fulfill their vector control, entomological monitoring, and environmental compliance mission		
• Mechanism in place to involve all stakeholders in the early design and planning of entomological monitoring, vector control, and environmental compliance activities		
• Mechanisms in place to educate and mobilize community to help reduce or eliminate vector breeding sites		
• Regular stakeholders meeting platform where entomological surveillance data and vector control coverages are discussed and used for decision-making		
• Linkage with universities and/ or research institutions for operational research and data sharing to inform vector control and policy formulation		
• Availability of financial and technical support for entomological monitoring, community education and mobilization, vector control and environmental compliance by partners		
• Please describe if there any challenges with regards to shareholders coordination and/or opportunities that enhance control of *Aedes* mosquitoes		
9. Insecticide Registration Status and Environmental Compliance		
• What insecticides are registered for public health use in the country?		
• Is there any law/policy that allows pesticides to be registered during a public health emergency situation, such as Zika?		

Thematic Area	Current Status As applicable: Specify administrative level (e.g. National, Provincial, District, etc.)	Recommendations As applicable: Specify audience (e.g. Government, Donors, etc.)
• What is the waste management capacity in country with respect to insecticide waste - specifically, are there high temperature facilities (including cement kilns) that meet the following specifications: • Commercially licensed facilities that are accredited and licensed by the host governments to dispose toxic waste; • Burn between 1100°C and 1300°C, with a minimum 2 second residence time in the afterburner chamber (hot zone) with excess oxygen (>11%) and with high levels of induced turbulence in the gas stream to promote complete combustion; • Have air scrubbers to ensure minimal impact to air quality.		
• Does the country require its own environmental assessment for use of public health insecticides, or can it use USAID's environmental assessments?		
• Is there a public consultation period for public health insecticides, and if so, does the emergency nature of the situation preclude public consultation?		
• Is there an environmental expert sitting within MOH, or what is the interface between the Ministries of Environment (or equivalent) and Health?		
• When was last time the country conducted an IRS and or larviciding campaign?		

ANNEX B: CONTACTS

Name	Organization	Title/Role
Theresa Tuaño	USAID	Economic Growth Office
Jason Landrum	USAID	Natural Resources Officer, Economic Growth Office
Joseph Torres	USAID	Regional Environmental Advisor
Leighann Kimble	URC-CHS (Assist Project)	Healthcare improvement fellow
Nadine Perrault	UNICEF	Representative, El Salvador
Dagoberto Rivera Rivera	UNICEF	Health and Nutrition Officer
Carlos Roberto Gazcón	PAHO	Representative, El Salvador
Franklin Hernandez	PAHO	Communicable Diseases Attaché
Rolando Massis López	MINSAL	Health Surveillance Director
Eduardo Romero Chéves	MINSAL	Vector Control Program Head
María Teresa Escalona Terrón	MINSAL	Communications Unit Head
Ana María Barrientos Hovet	MINSAL	Health Surveillance Unit Head
Oscar Núñez	URC-CHS (Assist Project)	Coordinator
Ernesto Pleites	MINSAL Instituto Nacional de Salud	Sub-Director
Keila Peña	MINSAL	Health Promotion Unit Head
María Eliette Valladares	CICA	Regional Health Director
Mauricio Guevara	Secretaría para Asuntos de Vulnerabilidad, Gobierno del Salvador	Miembro del equipo de apoyo del Secretario para Asuntos de Vulnerabilidad

ANNEX C: PROPOSAL FOR CIVIL PROTECTION ACTIVITIES FOR ZIKA RELIEF

NOMBRE DEL PROGRAMA: Intervención para la Reducción de Vulnerabilidades y Aumento de la Resiliencia Urbana en la Sub Cuenca Rio Acelhuate. Intervención Inicial en las Micro Cuencas, Matalapa, Ilohuapa y El Garrobo

PROYECTO: Captación y reutilización de agua lluvia en Centros Escolares y Comunidades.

PROBLEMA CENTRAL: Escasez del suministro de agua en zonas urbanas

OBJETIVO GENERAL: Propiciar la captación de agua en sectores donde la escasez de agua por largos períodos es crónica y potencia criaderos de zancudos

OBJETIVOS ESPECÍFICOS: Establecer prácticas en la población para el cambio de cultura en el manejo del agua lluvia

OE1: • Dotar a las comunidades de sistemas (barriles, tanques, pilas, canaletas etc.) para la captación de agua de lluvia

Actividad 1: a. dotar a familias de depósitos (barriles de 55 galones)

OE2: • Talleres para el manejo del agua lluvia.

Actividad 1: a. Taller captación, tratamiento y manejo del agua lluvia en el hogar,

ÁMBITO DEL PROYECTO: Microcuencas de Matalapa, Ilohuapa y El Garrobo

BENEFICIARIOS DIRECTOS: 6,500 personas de 2123 familias en 14 comunidad de los municipios de San Salvador y San Marcos del departamento de San Salvador, Antiguo Cuscatlan del departamento de La Libertad que reciben un suministro irregular de agua potable y 46,000 personas población educativa de 130 Centros Escolares de la zona sur del departamento de San Salvador.

RESULTADOS:

R1. 52,500 personas de 14 comunidades y 130 centros escolares fortalecidas sus capacidades y Resiliencia ante la escases del suministro de agua potable y/o enfermedades.

R2. Se mejora el estado de salud de la población beneficiaria al reducirse las enfermedades intestinales, al aumentar el aseo personal.

R3. Se reducen los criaderos de vectores que causan enfermedades transmisibles: dengue, chikungunya, Zika aumentar la capacidad de retención de agua.

DESCRIPCION: Este proyecto tiene como propósito fundamental fortalecer y consolidar el manejo apropiado de agua en el territorio a través de capacitaciones para mejora aprovechamiento de agua lluvia y prevenir criaderos de zancudos.

PRESUPUESTO:

Rubro	Capacitaciones	Comunidades	Centros Escolares	Días hábiles	Costos $	Subtotales $
Refrigerio	30			15	$ 2.00	$1,200.00
Consultores	2			15	$ 60.00	$900.00
depósitos para familia		14			$ 80.00	$169,840.00
cisternas para centros escolares			130		$2,965.00	$385,450.00
TOTAL						$557,390.00

EJECUTORES: Secretaria de Asuntos de Vulnerabilidad en coordinación con la Dirección General de Protección Civil, Prevención y Mitigación de Desastres.

MONTO TOTAL : $ 557,390.00

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REAL-WORLD IMPACT