ENTOMOLOGICAL MONITORING, ENVIRONMENTAL COMPLIANCE, AND VECTOR CONTROL CAPACITY

FOR THE PREVENTION OF ZIKA AND OTHER ARBOVIRUSES

GUATEMALA

ASSESSMENT REPORT

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

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Entomological Monitoring, Environmental Compliance, and Vector Control Capacity

for the Prevention of Zika and Other Arboviruses

Guatemala

Assessment Report

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ACRONYMS

BMPs	Best Management Practices
Bti	*Bacillus thuringiensis* var. *israelensis*
CDC	Centers for Disease Control and Prevention
HFG	Health Finance and Governance project
IEC	Information, education, and communication
LAC	Latin America and the Caribbean
MoH	Ministry of Health
	(*Ministerio de Salud Pública y Asistencia Social, MSPAS*)
NVCP	National Vector Control Program
PAHO	Pan American Health Organization
PPE	Personal protective equipment
PROEDUSA	Departamento de Promoción y Educación en Salud
QA	Quality assurance
RT-PCR	Reverse transcription polymerase chain reaction
TRI	Transmission risk index
ULV	Ultra low volume
USAID	United States Agency for International Development
ZC	Zika Committee

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 Guatemala, 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.

Zika transmission in Guatemala was officially recognized by the Government of Guatemala in late 2015. Since the beginning of 2016, Zika has been regularly identified throughout most of the country, as have other viral diseases borne by *Aedes aegypti*, such as dengue and chikungunya. Shortly after Zika was formally acknowledged by the government, a national-level committee was constituted with specialists in epidemiology, vector management, laboratory, behavior change communication, and health service delivery, among others. The Zika Committee meets on a weekly basis to review available data and discuss actions to respond to Zika at the national and subnational levels.

In addition to the Zika Committee, Guatemala has various elements in place that are critical to effective mitigation of the threat posed by *Aedes* mosquitoes. The national vector control program has developed guidance to steer vector control operations, and the chief entomologist of the program is well-qualified to oversee a countrywide approach to vector management. The number of staff at the central and subnational levels appears sufficient to adequately address the target vectors. A laboratory in Guatemala City can perform basic resistance tests and another can processes blood samples to detect Zika.

Yet in order to implement a credibly robust response to Zika, a number of key issues must be addressed. These include:

1. **Separation of technical and operational functions of vector management between two distinct Vice-Ministries.** The National Vector Control Program does not have formal supervisory authority over those at the subnational level that implement vector control efforts. This results in work that is largely autonomous, without technical oversight, and with little control over the quality of implementation.
2. **Inadequate financial support for vector management.** Financial resources for vector management are split between the two Vice-Ministries, limiting their efficient use. Of the limited resources that are available for each, most are used for vector management. Critical elements of the program, such as entomological monitoring, are thus underfunded and ineffective.
3. **Limited mobilization of communities for source reduction.** Efforts to further engage communities are limited by slim budgets that hinder the development and dissemination of Zika-related messaging.
4. **Surveillance of Zika-transmitting mosquitoes is not comprehensive enough to be useful.** Entomological surveillance is carried out twice yearly with qualitative indices. Unfortunately, these estimates have little association with disease transmission, and thus are of

minimal use in targeting vector control measures and determining their efficacy. The lack of a centralized, Internet-based database complicates the landscape further.

5. **The ability to conduct biological efficacy and resistance testing of larvicides and adulticides is minimal.** Similarly, the capacity to evaluate and monitor chemical-based intervention methods is also weak. The degree to which local vector populations are resistant to methods currently in use is unknown. Moreover, the capacity to evaluate the effectiveness of alternative insecticides on *Aedes* populations is limited.

6. **Lack of a comprehensive insecticide management strategy.** There is currently no strategy to ensure that storage facilities for insecticides and the protocols for their transport, use, and disposal are in compliance with regulations. Facilities in the country are not equipped to ensure the safety of those that work in them.

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

1. Streamline the supervisory relationship between the technical and operational components of vector management, and ensure ample funding for *Aedes* control activities
2. Scale up educational campaigns to promote environmental management and source reduction and improved personal protection from *Aedes* mosquitoes
3. Establish a more rigorous entomological surveillance program for Zika-transmitting mosquitoes, including development of an online repository to collect and disseminate data
4. Fast-track studies to determine the resistance status of the local *Aedes aegypti* population, while laying the foundation for yearly resistance testing
5. Build the capacity of the vector control workforce via short-term training programs in medical entomology, on-the-job training, and routine supervisory visits
6. Establish and implement an environmentally compliant insecticide management strategy

I. 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 Guatemala took place from July 11 to July 21, 2016. The assessment team interacted with various stakeholders including representatives from the following institutions and organizations:

- Ministry of Health (MoH) of Guatemala (*Ministerio de Salud Pública y Asistencia Social, MSPAS)*
- USAID/Guatemala
- USAID/Washington DC
- U.S. Centers for Disease Control and Prevention (CDC)
- Pan American Health Organization (PAHO)

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 Guatemala

Guatemala is located in Central America and borders Mexico, El Salvador, Belize, and Honduras. It has 15,189,958 inhabitants (est. 2016), living over 42,042 mi^2 of territory; slightly more than half (51.6%) of the population is urban.[4] Almost all Guatemalans are considered to be at risk of being infected with Zika and other arboviral diseases, since the majority of the country is infested with the mosquito vectors *Aedes aegypti* and *Aedes albopictus*. Although not confirmed via entomological means, it is believed that people living in the western highlands (i.e., the mountainous regions of Huehuetenango, Quetzaltenango, San Marcos, and Totonicapán) are at a reduced risk due to altitudes that reach more than 7,500 feet (ft.) above sea level.

Zika transmission in Guatemala was officially recognized by the Government of Guatemala in late 2015, although samples sent to CDC in Atlanta demonstrated that the virus had been circulating in the country as early as April 2015. Since the beginning of 2016, Zika has been regularly identified throughout most of the country, as have other viral diseases borne by *Aedes aegypti*, such as dengue and chikungunya.

The bulletin for epidemiological week 30 of 2016,[5] which includes data for 2016 through to July 30, reported 2,280 suspected cases of Zika (incidence rate, IR=14.1 per 100,000 inhabitants) from 27 of the 29 Health Areas in the country.[6] Over the same 30 weeks, all four serotypes of dengue have circulated in the country, with a reported total of 4,713 suspected cases (IR = 29.1) in 27 of 29 Health Areas. There were 6 confirmed cases of severe dengue (out of 28 processed samples). The number of cases of chikungunya reported over the same period was 2,960 (IR = 18.3) in 27 of 29 Health Areas.

Reporting of all three diseases throughout the country reflects the magnitude of the problem of arboviral diseases in Guatemala. The low positivity rate of samples may indicate that the diagnostic capacity of clinical personnel at various levels of the health system is not attuned to these diseases and that patients may have one of these diseases as much as another unknown malady such as the flu. The assessment team was not informed as to the fate of negative samples of any of the three diseases, such as whether they were cross-matched to determine if a negative case of one of the three diseases might be a positive case for one of the others.

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[4] https://www.cia.gov/library/publications/the-world-factbook/geos/gt.html

[5] http://epidemiologia.mspas.gob.gt/files/Publicaciones%202016/SEMEPI/SEMEPI_30_2016.pdf

[6] Each of Guatemala's 22 departments is a Health Area, with Guatemala City and Petén subdivided into multiple areas. Each Health Area contains departmental health and related facilities, including health clinics, ambulatory care, and vector control. The Health Area is where human, physical, and financial resources are administered, and the level at which epidemiological information is made available.

2.2 Vectors of Arboviral Diseases and their Distribution in Guatemala

In the Americas, *Aedes aegypti* has been implicated as the primary vector of all four serotypes of dengue virus, chikungunya virus, and Zika virus (*Aedes albopictus* is suspected as being a secondary vector).[7,8] *Aedes aegypti* prefers to feed on humans (as opposed to *Albopictus*) and generally favors breeding sites that are in relative proximity to humans, such as manmade containers found in and around households. Many closely-related *Aedes* species, such as *Aedes bahamensis* and *Aedes mediovitatus,* are able to transmit Zika, but are not currently considered to have a significant role in Zika transmission.

Although the assessment team was unable to obtain entomological data on vector distribution in Guatemala, it is probable that *Aedes aegypti* is ubiquitous throughout the country and particularly so in more urban locations. The same is also probably true for *Aedes albopictus*. *Aedes aegypti* is commonly found at high elevations, such as at 5,600 ft. in Mexico[9] and up to 7,600 ft. in Colombia.[10] For this reason, *Aedes Aegypti* are thought to exist across most of Guatemala, except at the highest elevations—the mountains in the western highlands with elevations above 7,500 ft. Dengue outbreaks have been reported in León, México (5,900 ft.), and in Colombia, dengue-infected mosquitoes were found at an altitude of 6,500 ft.[7]

2.3 Vector Control Interventions in Guatemala

Vector control in Guatemala, while limited, is conducted through the integration of several approaches. The countrywide approach for prevention and control of dengue, and thus Zika, is centered on the main cities and towns of the country. Control efforts in these locations include sporadic vector suppression, based on bi-annual entomological surveillance data, with thermal fogging and truck-mounted ultra low volume (ULV) machines. There is also widespread application of temephos in water containers as a larvicide, though evidence from neighboring countries suggests that the vectors in Guatemala may be resistant.[11] Source reduction (i.e., elimination and management of water-holding domestic containers) is conducted by designated technicians at the Health Area level and complemented by mobilization of communities to assist with environmental sanitation. Although few have been launched, behavior change campaigns are another element in the fight against Zika and focus on providing Guatemalans with skills and knowledge to avoid transmission.

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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] 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.

[10] Ruiz-López F, González-Mazo A, Vélez-Mira A, Gómez GF, Zuleta L, Uribe S, Vélez-Bernal ID. Presencia de *Aedes (Stegomyia) aegypti* (Linnaeus, 1762) y su infección natural con el virus dengue en alturas no registradas para Colombia. Biomédica. 2016;36:303-308.

[11] 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

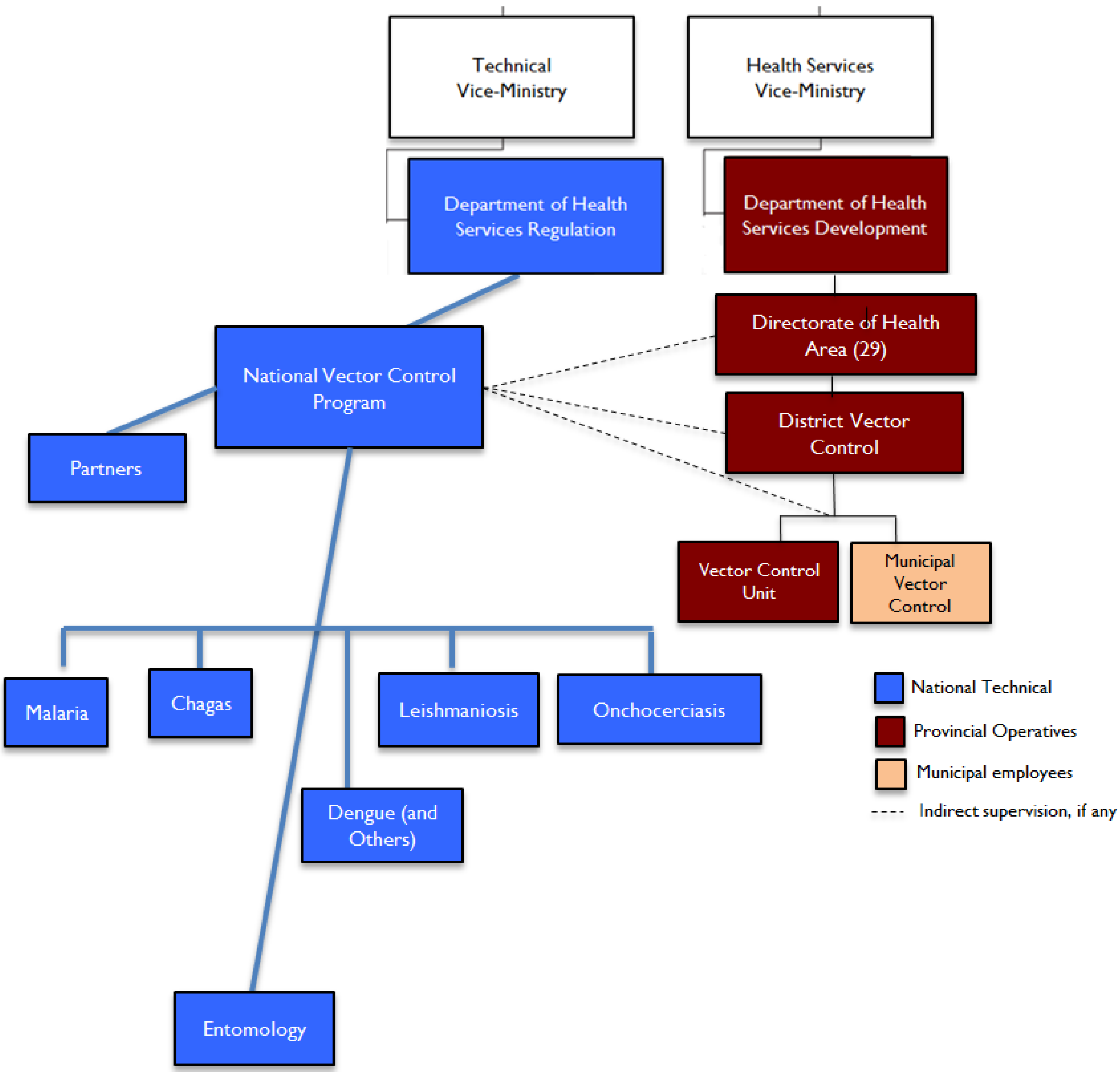
3.1 Place, Structure, and Financial Resources of Entomological Surveillance and Vector Control

3.1.1 National Level

The MoH in Guatemala is composed of four distinct Vice-Ministries,[12] two of which play a role in the design, planning, and implementation of entomological monitoring and vector control activities in the country. Within the Technical Vice-Ministry, presented in blue in Figure 1, sits the National Vector Control Program (NVCP), essentially a vertical program with links to other government departments and external organizations. The national program is responsible for setting the overarching strategy for vector control in the country and developing and maintaining the requisite guidelines, protocols, and tools to achieve its objectives. Contained within the Health Services Vice-Ministry, displayed in red in Figure 1, are all operational aspects of the program, notably control and monitoring activities at the subnational level. With technical and operational functions existing under separate Vice-Ministries, the national-level entomologists that lead the NVCP and set its direction have no formal supervisory authority over those at the subnational level who implement program activities. As a result, subnational components of the program are largely autonomous and plan and conduct their work without input from the Technical Vice-Ministry at the central level.

[12] At the time of the assessment, there were four Vice-Ministries. There are now two.

FIGURE 1: ORGANIZATIONAL STRUCTURE, MOH, TECHNICAL AND HEALTH SERVICES VICE-MINISTRIES (UNOFFICIAL)



The National Program receives verbal support and encouragement from authorities and stakeholders within various levels of the MoH and other governmental and non-governmental sectors of the country. This includes Civil Protection, Ministry of Education, Ministry of Tourism, armed forces, municipal officials, local leaders, the general public, and private medical facilities. While there is widespread enthusiasm for the program and encouragement for its expansion, this has not translated into adequate funding for its implementation. Although precise figures were not made available to the assessment team, it is clear that the majority of Zika-focused resources in the country are directed at detection and treatment of cases. Of the limited resources purposed for vector management, most are used for control activities as opposed to entomological surveillance. Moreover, the national program does not have dedicated vehicles and logistical support with which to travel to supervise and assess field activities.

3.1.2 Subnational Level

There are approximately 370 entomological monitoring and vector control units at a subnational level. These units cover all 333 municipalities in the country, and thus all 29 of the country's Health Areas. Some larger municipalities have more than one unit tasked with vector control, though none of the units is intended solely to focus on managing mosquito populations. The units are made up of one field worker and one field supervisor, both on indefinite loan from other posts within the MoH.

For the purposes of maintaining a high standard of vector control across the country, the units are, in theory, supposed to regularly interact with the central level to plan, manage, and report activities. In practice, however, and as mentioned above, the units plan their work at the district level and largely without input from the expert entomologists of the National Program in Guatemala City. All operational details pertaining to entomological surveillance and control are monitored and controlled by the Health Services Vice-Ministry. Vector control interventions are thus conducted without direct involvement of the NVCP, limiting opportunities to monitor and evaluate control activities and to build staff capacity in mosquito control efforts.

Though the units are autonomous in where they operate and what they do, budget and logistical support for subnational vector control operations is managed at the central level by the Health Services Vice-Ministry. Within that budget, which has been reported to be rarely released as needed, there is no specific funding for arboviral diseases transmitted by container-inhabiting *Aedes* species. As a result, *Aedes* control activities are carried out in an *ad hoc* manner and largely in response to disease outbreaks. Specific control efforts against *Aedes aegypti* are infrequent, small-scale and unlikely to have much of an impact on the vector or the arboviruses they transmit.

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

3.2.1 National Level

Although dengue transmission in Guatemala was thought to have first occurred in 1978, it was not until a few years ago that the Dengue Technical Group (Mesa Técnica de Dengue) was formed. The group's focus was initially one of disease epidemiology, medical care, and control of dengue vectors. Over time, its focus expanded and morphed in accordance with disease outbreaks. The group was known as the Chikungunya and Dengue Group from 2014 and is now referred to as the Zika Committee (ZC). International entities, such as CDC, the Pan American Health Organization (PAHO), and neighboring governments, provide periodic technical support.

3.2.2 Subnational Level

The only efforts identified by the assessment team to engage stakeholders and communities to control *Aedes* mosquitoes are coordinated by the "Departamento de Promoción y Educación en Salud" (PROEDUSA). The role of the department is to build community knowledge through dissemination of information, education, and communication (IEC) materials in face-to-face sessions or in print. While the department has more than 300 staff, IEC efforts are often curtailed by lack of a dedicated budget and logistical support. With respect to Zika, the department has designed and printed pamphlets and posters; these materials, however, were not reviewed by the country's vector control experts.

Anecdotal evidence points to the mobilization of communities in campaigns to reduce potential mosquito breeding sites. Aside from an article printed in a national newspaper in February 2016, tangible evidence of such activities was not obtained during the visit.[13] As a result, the breadth to which communities are mobilized to address Zika is unknown, as is the effectiveness of their actions.

FIGURE 2: CAMPAIGN TO ERADICATE MOSQUITO BREEDING SITES

3.3 Human Resources

3.3.1 National Level

In the Technical Vice-Ministry at the national level, there are 20 staff. This includes the program director, national public health entomologist, and personnel responsible for control of malaria, Chagas, leishmaniasis, and arboviruses (i.e., Zika, dengue and chikungunya). The one public health entomologist in the program is sufficiently qualified to develop, coordinate, and evaluate a national plan for the control and surveillance of arboviral vectors. This includes creation of guidelines, protocols, and implementation plans. Yet even with a greater number of similarly qualified staff, the MoH division—considering the technical and operational elements of vector control—significantly impedes the effective execution of such a plan at the subnational level.

National-level vector control personnel have the capacity to manage an insectary and undertake larval and adult susceptibility tests, although they have never done so with *Aedes* mosquitoes. They are also able to morphologically identify the different vectors, though appear to lack the capacity to conduct biochemical and molecular analysis. Given the limited staff complement and inefficient reporting lines, the program's capacity to train people at the peripheral level and ultimately maintain a well-trained pool of technicians is limited. Moreover, there is no evidence of capacity to identify and map high-risk geographical areas to monitor change in vector density and behaviors over time.

3.3.2 Subnational Level

Each of the 29 Health Areas has two technicians—one responsible for vector control and one for entomological surveillance. These 58 technicians are in charge of 1,331 operational personnel that carry out vector surveillance and control activities. Their work is planned, monitored and supervised in each district by Departmental Health Directors. The total of vector control technicians appears sufficient to provide adequate vector control throughout the country. Yet, as previously mentioned, the principal technical advisors for vector control in the country (from the National Vector Control Program) do not

[13] http://noticias.com.gt/departamentales/20160208-san-marcos-estudiantes-limpieza-evitar-zika.html

have a direct supervisory role over field activities or the individuals that conduct them. Consequently, there is no quality assurance from those most equipped to oversee field activities. While this likely results in substandard performance at the field level, absent routine monitoring, it is difficult to ascertain the degree to which implementation deviates from best practices.

3.4 Infrastructure

3.4.1 Presence of Reference Laboratory at the National Level

Laboratory staff from the NVCP claimed to have been trained to conduct larval and adult bioassays to detect chemical resistance using the CDC bottle bioassay technique. There are indications, however, that their capacity to conduct significant Zika-related insecticide resistance monitoring and evaluation activities is limited. Staff have run tests with *Anopheles* mosquitoes, for which additional training would be needed having never worked with *Aedes*. They also require support to run Reverse Transcription Polymerase Chain Reaction (RT-PCR) and other vector-borne disease oriented tests.

The National Public Health Laboratory in Guatemala City only processes human blood samples to detect Zika and other Arboviruses provided they have reagents; no tests are undertaken to confirm viral presence in mosquitoes. Unfortunately, the assessment team was not provided with sufficient information to make further conclusions about the laboratory's bio-chemical analysis capacity.

3.4.2 Functional Insectary

There is one national-level insectary, and it has two laboratory technicians who are trained and competent to perform the basic functions of an entomological laboratory. This includes identification of adult and larval stages of the primary and secondary Zika vectors, *Aedes aegypti* and *Aedes albopictus*. The insectary consists of a single 20x20 ft. room, situated in a rundown building with unclean floors and walls, shelves, cages, and trays in disrepair, scarce supplies, poor lightning, and little prospect for regulation of heat and humidity. Nevertheless, it harbors laboratory mosquito colonies of three species that have been kept for quite some time: *Anopheles albimanus, Aedes aegypti* (estimated at about 30 years old), and *Culex quinquefasciatus*. Each species is separated by its placement in a different part of the room, with both larvae and adults reared on location. Despite the lack of light, temperature, and humidity control, the mosquitoes were very well kept. The *Aedes aegypti* colony could be used as a reference susceptible strain for insecticide resistance monitoring of field-caught mosquitoes.

In order to rear field colonies, more space and separate rooms would be necessary to handle insecticides for insecticide resistance bioassays. If provided with training and additional equipment, more advanced functions, such as the ability to detect biochemical and genetic resistance levels by molecular analysis (i.e. PCR), could also be implemented. At present, the insectary lacks the capacity to produce large numbers of mosquitoes to do resistance testing, pooling, and processing of mosquitoes for virus isolation, and anything else that extends beyond simple breeding.

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

3.5.1 National Level

A general, national vector control plan was developed in February 2016 (*Plan Operativo para el Abordaje Integral de Zika, dengue, chikungunya*). Input was provided from multiple stakeholder departments and units of the MoH, including the NVCP, the Department of Epidemiology, and the National Laboratory.

The plan contains sufficient detail to allow for implementation across the country, the responsibility of which ultimately falls to Health Area Directors. Given the MoH structure, it becomes difficult for the NVCP to oversee its implementation and validate the quality of the plan.

Mapping of transmission risk from the various arboviral diseases is limited in Guatemala and based entirely on the epidemiology of clinically-diagnosed cases. Data are collected at the subnational level, after which is transmitted to the national level. There is little evidence to indicate use of the data in the planning and implementation of short-term, vector control activities at the subnational level. Its usefulness is therefore limited to the preparation of endemic channels.

Entomological surveillance in Guatemala is carried out twice a year, using largely qualitative methods. There is no sizeable surveillance of Zika-transmitting mosquitoes in the country, and therefore no data for use in mapping vector distribution and targeting vector control activities. Moreover, the infrequency of collection limits the comparability and thus usefulness of collected data to the moment in which it was obtained. This results in control efforts that are not directed to areas where entomological risk is highest, because it is virtually impossible to determine where that condition is met. Even if such data were available, the government does not have a networked database within which to facilitate efficient collection and dissemination of data amongst stakeholders.

3.5.2 Subnational Level

Given the distinction between the Technical and Health Services Vice-Ministries and their roles in vector control, the development of a subnational-level plan would likely require significant support from the NVCP.

3.6 Implementation Capacity

The NVCP has developed adequate guidelines, protocols, and manuals to guide field operations targeting *Aedes* mosquitoes. It is assumed, however, that the capacity to effectively implement at the operational level is minimal. Yet National Program staff cannot provide solid evidence for or against such a conclusion without direct supervision of implementation. Unfortunately, the current organizational structure fails to facilitate such oversight.

As mentioned in section 3.1, there is limited funding for vector control in Guatemala. This lack of resources is considered a major impediment to effective implementation and is one of several barriers that prevent the National Program and subnational entities from managing Zika vectors. Although limited and implemented in an ad hoc manner, existing vector control methods include the use of handheld thermal fogging, high volume spraying with motorized backpack sprayers, truck-mounted ULV, and direct application of larvicides (e.g. *Bacillus thuringienesis var. israelensis (*Bti), and the organophosphate, temephos. The effectiveness of these measures is not monitored and thus unknown.

There is little evidence in Guatemala of entomological monitoring of the primary vectors of Zika transmission. As a result, the composition, distribution, and seasonality of Zika vectors are largely undetermined. Even with a more robust monitoring system, the scarcity of formally trained entomologists in the country presents an obstacle to detecting changes in vector density and behavior and to analyzing entomological data for vector control and/or reporting purposes. At the subnational level, a lack of financial and human resources precludes the establishment of a community-wide survey of *Aedes* aquatic stages.

As reported in section 3.4, personnel and infrastructure limitations prevent adequate performing of tests of insecticide resistance. Obtaining the resistance status of local *Aedes* populations would help to minimize the selection pressure on the vectors and ensure the use of insecticides to which local vectors are susceptible.

There is solid evidence on the role of source reduction and environmental management as effective complements to insecticides in a comprehensive and robust vector control program. Although actively encouraged in Guatemala, the extent to which Zika-related source reduction and environmental management occur is unclear. As noted in section 3.2.2, there is some evidence of community-led efforts to reduce existing and potential *Aedes* breeding sites.

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

The disease surveillance system in Guatemala reports cases of notifiable diseases disseminated via a weekly bulletin. A central database system links to district-level clinics where service data are recorded. Data can then be accessed and analyzed at the central level to implement response plans as needed to quell potential outbreaks. Unfortunately, a similar system does not exist to capture and house data related to entomological surveillance, environmental compliance, and vector control.

Entomological data, where present, is initially recorded on paper forms after which it is digitized and stored on local computers. There are standard worksheets, designed to facilitate vector monitoring and control, as included in the *Manual operativo de vigilancia y control entomológico de Aedes aegypti vector del dengue (y chikungunya) en Guatemala*. The extent to which these worksheets are used at the field level to gather relevant data, inform implementation, and report to higher levels of the system is unclear. Similarly, little information was afforded to the assessment team to enhance understanding relevant to how data flows from departments to the national level (e.g., through online channels, telephone, fax, or by hand), and how often it moves.

3.7.2 Capacity to Analyze and Interpret Data

To inform the planning and implementation of Zika vector control activities, data must be comprehensive, easily accessible, and manipulated by individuals with sufficient capacity to transform the data into usable information. Unfortunately, comprehensive surveillance and vector control data are unavailable in Guatemala due to a limited number of field workers, inefficient supervisory structures, and the lack of a centralized database to upload and then access data. There are, however, individuals in the vector control program capable of analyzing and interpreting entomological data (in conjunction with epidemiological data) to guide control activities against *Aedes aegypti* and *Aedes albopictus*. If reliable entomological data were made available, Guatemala would have enough resources to conduct basic analysis, mapping, and dissemination of data to relevant government departments and other stakeholders.

3.7.3 Capacity to Produce High Quality Reports

A definitive determination could not be made on the subject as no reports were shared with the assessment team.

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

3.8.1 National Level

The assessment team was unable to verify the level or quality of stakeholder engagement and use of entomological data through interviews conducted while in-country. The only verified element of entomological information used to guide vector control operations is house infestation level (i.e., proportion of houses with *Aedes Aegypti* presence) before and after the implementation of vector control measures.

3.8.2 Subnational Level

At the departmental level, entomological data to inform vector control activities are also limited to before and after house infestation rates. As previously mentioned, there is evidence of community participation in cleaning campaigns for source reduction of mosquito breeding sites. No relevant documentation was shared with the assessment team, for which the frequency of such events was unable to be confirmed.

3.9 Insecticide Registration Status and Environmental Compliance

Insecticide registration in Guatemala falls under the purview of the agricultural sector, namely MAGA, the Ministry of Agriculture, Livestock, and Food. The last formal government act covering the registration, commercialization, and use of insecticides was enacted in 1990.[14] There are only 25 forbidden pesticides in the country; all are also recognized internationally for the risk they pose to humans and/or other wildlife.[15] Although an updated list of insecticides registered for public health purposes was not made available to the assessment team, insecticides in use for Zika control in Guatemala are the larvicide temephos and the adulticide pyrethroid deltamethrin.

In Guatemala, there are no facilities equipped for the final disposal of empty insecticide containers, nor are there protocols to guide their removal from the environment. At the department level, most insecticide storage facilities fail to comply with minimum safety standards, including stocking and storage of expired products; presence of used and/or empty insecticide containers; improper storage and maintenance of application equipment; insufficient ventilation; and limited personal protective equipment (PPE) for those active in applying insecticides.

Guatemala has existing facilities that could allow for the safe storage of large amounts of insecticides and application equipment. Yet, the facilities would need to be overhauled to comply with Best Management Practices (BMPs) pertaining to the proper storage and handling of insecticides. Similarly, the national program would need to emit guidance on BMPs for proper transport, use, and disposal of insecticide waste after spray campaigns. Individuals working at the operational level would also require training on spill prevention and adequate cleaning procedures in the case of insecticide spills in accordance with BMPs. Spill kits and emergency protocols would have to be provided to all warehouses as well as vehicles transporting hazardous materials.

[14] Oficina de normas y procedimientos de Guatemala. Acuerdo Gubernativo No. 377-90: Reglamento sobre registro, comercialización, uso y control de plaguicidas agrícolas y sustancias afines, 1990.
[15] http://www.prensalibre.com/el-maga-registra-25-quimicos-prohibidos

4. KEY ISSUES AND CHALLENGES

Vector Control in Guatemala has some elements in place for the country to mount a credible response to the threat posed by *Aedes* mosquitoes. The public health entomologist that oversees the technical aspects of the program is adequately qualified to develop, coordinate, and evaluate a national plan for the control and surveillance of these vectors. Guidelines, protocols, and manuals have been developed and are sufficient to guide control operations. The national program has the support of authorities and stakeholders at various levels of the MoH and within other governmental and non-governmental entities of the country. A committee regularly meets to address issues related to disease epidemiology, medical care, and vector control. The total of individuals at the central level and throughout the country appears sufficient to deliver adequate vector management. There is a reference laboratory with staff that can conduct rudimentary resistance tests and another laboratory that processes blood samples to detect Zika.

On the other hand, there are several key issues that hinder the country's ability to effectively respond to the challenges posed by Zika and other arboviral diseases:

1. **Technical and operational functions for vector management are contained within two separate Vice-Ministries (i.e., Technical and Health Services).** The national-level entomologists that lead the NVCP have no supervisory authority over those at the subnational level that operationalize program vision. As a result, subnational components of the program are largely autonomous and plan and conduct their work without input and oversight from those most equipped to provide it. Without routine supervision, it is difficult to ascertain the degree to which implementation deviates from standard best practices.
2. **The budget for vector management in Guatemala is insufficient to credibly respond to Zika.** Moreover, it is split between the two Vice-Ministries mentioned above. Of the limited resources available, most are used for vector management, thus leaving little for critical elements of the program such as entomological monitoring. Similarly, the National Vector Control Program is without easily accessible vehicles and logistical support to supervise and assess field activities.
3. **While evidence points to the mobilization of communities to reduce mosquito breeding sites, this phenomenon is likely not widespread.** IEC efforts to engage communities are impeded by budgetary restrictions and thus lack of support for logistics and dissemination of Zika-related messages.
4. **Surveillance of Zika-transmitting mosquitoes is limited, as is data to map vector distribution and target control activities.** Entomological surveillance in Guatemala is carried out twice a year, using largely qualitative methods to determine pre- and post-treatment house infestation levels. Unfortunately, these estimates have little or no association with disease transmission, and thus are of minimal use in determining the ultimate efficacy of vector control measures. This results in control efforts not directed to areas where entomological risk is highest; it is virtually impossible to determine where that condition is met. Even with a more robust vector surveillance program, the lack of a centralized, Internet-based database impedes potential use, dissemination, and reporting of surveillance data.
5. **The ability to conduct biological efficacy and resistance testing of larvicides and adulticides in the country is minimal.** Similarly, the capacity to evaluate and monitor chemical-based intervention methods is also weak. The degree to which local vector populations are

resistant to methods currently in use is unknown. Moreover, the capacity to evaluate the effectiveness of alternative insecticides on *Aedes* populations is limited.

6. **Guatemala lacks a comprehensive insecticide management strategy.** Such a strategy would ensure that insecticide storage facilities and the protocols for transport, use, and disposal of insecticides comply with local and international regulations. Facilities in the country are ill-equipped to ensure environmental compliance and the safety of those that work within them.

5. RECOMMENDATIONS

5.1 Recommendations to the Government of Guatemala

1. **Streamline the supervisory relationship between the technical and operational components of vector management.** For the National Vector Control Program to be an effective vehicle in efforts to thwart Zika, it should have full control over the planning, implementation and monitoring of the response. Technical and operational aspects for vector control would be housed within the same Vice-ministry. In addition, national-level officials would have greater presence at the subnational level to ensure activities are implemented as planned. As restructuring involves a lengthy process of managing a complicated change, the MOH could initiate a pilot whereby national-level tools and resources are directed to an individual priority area first, and expanded to neighboring sites in the future.
2. **Ensure funding for Aedes control activities.** The integrated plan to respond to arboviral diseases in Guatemala, including Zika, was finalized in February 2016. To operationalize the activities within the plan, greater support is essential, as is streamlining the funding through one governmental body as opposed to two separate Vice-Ministries. Until structural changes can be undertaken, the national control program should be more involved in recommending spending for vector management, even outside of the program's purview.
3. **Scale up environmental management and source reduction.** Environmental management and source reduction are critical components of an integrated mosquito control program and a solid complement to larviciding and adulticiding efforts. Community participation is essential to this, particularly in the management of used and unused containers. Community groups should be formed and/or identified, trained as needed, and equipped to manage their communities and homes. Another option is strengthening alliances with other government sectors (e.g. civil protection, education, agriculture, and the armed forces) to foster a more holistic response. These actions would help to augment the effectiveness of vector population suppression efforts, and reduce populations beyond what can be achieved with insecticides.
4. **Strengthen entomological surveillance of Zika-transmitting mosquitoes.** To better ascertain the relationship between vector abundance and disease transmission, entomological surveys should be undertaken at least four times per year. Even better, surveillance could be conducted to produce weekly estimates of abundance, and then combined with mapping of homes of individuals suspected to be infected with Zika (or other arboviruses) to generate a transmission risk index. The index would guide vector control activities to halt the chain of transmission. Adjustment to current surveillance methods would require training of those required to carry it out; in this case, field technicians would be the primary focus.
5. **Fast-track studies to determine the resistance status of the local Aedes aegypti population.** To ensure the effectiveness of vector control efforts, studies must be undertaken to determine the resistance status of local vector populations to larvicides and adulticides currently in use, as well as those that could be used in the future. Findings would be used to develop a national insecticide resistance management plan that includes resistance mitigation approaches such as rotation of insecticides in use. Testing would ideally be carried out at least once a year, updating the management plan as new and relevant evidence emerges.
6. **Establish and implement an environmentally compliant insecticide management strategy.** The government of Guatemala is in need of an insecticide management strategy that

ensures insecticide storage facilities and the protocols for handling, transport, use and disposal of insecticides comply with local and international regulations. While current facilities permit the storage of large amounts of insecticides and spray equipment, they require updating to be sufficiently in line with universally accepted guidelines.

5.2 Recommendations to Donors

1. **Provide funding for a short-term training program in medical entomology.** Such an offering would include mosquito rearing and testing, surveillance and control operations, environmental compliance, and IEC. The course could be administered by bringing in specialized trainers, or delivered via a more cost-effective platform such as PAHO's virtual campus [https://www.campusvirtualsp.org/en]. The latter option could facilitate communication and knowledge-sharing opportunities for participants from across the LAC region.
2. **Support a quality assurance (QA) specialist (or program) for vector control.** The current separation within the MOH of the technical and operational functions of vector control prevents proper oversight of field-based control activities. Resolving this merits organizational restructuring, which is not likely to be accomplished in the short-term. As a more immediate, stopgap measure, donors should consider supporting a QA specialist (or program), charged with resolving bottlenecks that pose an impediment to proper vector control. This could include addressing capacity issues via on-the-job training; assessing and supporting vector control and surveillance through routine supervisory visits; and spearheading evaluations to determine the most effective vector management techniques.
3. **Support recommendations to the government of Guatemala by providing funding or in-kind contributions**. This support could include:
   - ***Costs associated with establishing a more rigorous entomological surveillance program, perhaps with ovitraps.*** This would include development of an online system to capture and disseminate epidemiological and entomological surveillance data as well as vector control operations in all 29 Health Regions. The program would also require support for data collection activities, such as supplies (e.g. ovitraps, filter paper, and stationery), transportation expenses, and communication materials.
   - ***A large-scale educational campaign to ensure Zika-related communications reach communities most susceptible to transmission.*** The campaign would be designed by experts in behavior change communication with the objective of promoting improved personal protection from mosquitoes and source reduction and environmental management. This could include diverse printing materials, massive media outreach (i.e. radio and television), and workshops and meetings at the national, departmental, and community levels.
   - ***Essential equipment and supplies for an entomology laboratory and separate insectary.*** The MOH would provide the space, and donors the materials needed to make it functional. The insecticide testing facility would be separate from the mosquito-rearing facility to avoid contamination.

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
Romeo Menéndez	USAID/Guatemala	Health Program Specialist/ Zika Coordinator
Regina Soto de Colindres	USAID/Guatemala	Environmental Protection Specialist, Office of Economic Development
Natalia Machuca	USAID/Latin America and the Caribbean Bureau, DC	Health Development Officer
Joseph Torres	USAID/Central America Region	Regional Environmental Advisor, Central America and Mexico
Reina Turcios-Ruiz	CDC/Central America Office	Director
Loren Cadena	CDC/Central America Office	Deputy Director, Global Disease Detection
Andrés Espinosa	CDC	
Judith Garcia	MOH	Directorate of Epidemiology
Luis Arturo Morales	MoH, Sistema Integral de Atención en Salud	Director
Orlando Cano	MoH, Sistema Integral de Atención en Salud	Advisor to the Director
Zoraida Morales Monroy	MoH, NVCP	Director
Sayra Chanquín	MoH, NVCP	Deputy Director
Adrián Ramirez	MoH, Programa de Enfermedades Transmitidas por Vectores, Subvencion Malaria	Expert in Information Technology
Jorge Matute	MoH, Centro de investigaciones en nutrición y salud	Associate Researcher
Jaime Juarez	PAHO/WHO	Communicable Diseases
Celia Cordón de Rosales	Universidad del Valle de Guatemala	Director, Center for Health Studies Research
Olga Torres	Diagnóstico Molecular, S.A. (Private Organization)	Director

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