ENTOMOLOGICAL MONITORING, ENVIRONMENTAL COMPLIANCE, AND VECTOR CONTROL CAPACITY

FOR THE PREVENTION OF ZIKA AND OTHER ARBOVIRUSES

HAITI

ASSESSMENT REPORT

September 2016
This publication was produced for review by the United States Agency for International Development. It was prepared by Paul Reiter and Alan Wheeler for the Health Finance and Governance Project.

The Health Finance and Governance Project

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CONTENTS

ACRONYMS

BCC	Behavior change communication
Bti	*Bacillus thuringiensis* var. *israelensis*
CARPHA	Caribbean Public Health Agency
CDC	Centers for Disease Control and Prevention
DELR	Direction d'Épidémiologie, de Laboratoires, de Recherche
DOSS	La Direction d'Organisation des Services de Santé
GIS	Geographic information system
HFG	Health Finance and Governance project
HR	Human Resources
IEC	Information, education, and communication
IRS	Indoor Residual Spraying
LAC	Latin America and the Caribbean
LNSP	Laboratoire National de Santé Publique
MSPP	Ministère de la Santé Publique et de la Population
PAHO	Pan American Health Organization
PCR	Polymerase chain reaction
PNCM	Programme National de Lutte Contre la Malaria
PPE	Personal protective equipment
QA	Quality assurance
qPCR	quantitative real-time PCR
RT-PCR	Reverse transcription polymerase chain reaction
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 Haiti, 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 June 8 to 17, 2016, and sought to appraise 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 assessment identified several challenges that must be confronted in order to mount an adequately robust response to the threat of Zika in Haiti:

1. Currently there is no national body to coordinate, plan, and finance a widespread and sustained vector control effort to suppress Zika transmission.
2. Haiti's existing vector surveillance and control workforce is inadequately staffed with only 12 brigades of five personnel each for the entire country.
3. There is no sizeable program for surveillance or control of Zika vectors in the country, nor is there a central database for reporting surveillance and vector control efforts.
4. Weak infrastructure for waste management and water supply make households susceptible to mosquito breeding via shallow containers and uncovered water storage vessels. This suggests an imperative for environment-centered treatment strategies.
5. Women of reproductive age and pregnant women in particular are a high-risk population. Reaching them with behavior change communication (BCC) and information, education and communication (IEC) activities is challenged by low levels of antenatal care coverage.

Based on these findings, the assessment team recommends that the Government of Haiti, with external support, should:

1. Establish a national steering committee or vector control technical working group, comprised of Haitian government agencies, donors, implementing partners, NGOs, and community organizations.
2. Implement short-term response measures to maximize protection of those most at risk of Zika transmission. Given the current state of Zika circulation in the region and its presence in Haiti, there is a pressing need to limit its spread through support of vector control activities, distribution and use of personal repellants, and dissemination of Zika-related BCC messages. The response in Haiti should specifically target the Ouest, Artibonite, and Nord departments, where 63 percent of the population and 70 percent of putative cases exist.
3. Initiate nationwide surveillance, vector control, and prevention interventions with a particular focus on the three departments with the highest number of cases – Ouest, Artibonite, and Nord. Immediate interventions should focus on source reduction while pilots of promising

control practices are undertaken (e.g. indoor residual spraying and perifocal treatments). Any large-scale insecticide purchase should be avoided until resistance status is better known.

4. Catalyze long-term efforts to improve in-country capacity to respond to Zika and similar outbreaks in the future. The objective of these efforts would be to improve control and surveillance activities against the mosquito vectors of arboviruses, primarily *Aedes aegypti*. Activities would include developing an eLearning platform, strengthening information systems, and improving quality assurance mechanisms.

5. Facilitate regional knowledge sharing to exchange information on epidemiological and entomological trends, as well as successful virus prevention and vector control measures.

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 Haiti took place from June 8 to 17, 2016. The assessment team interacted with various stakeholders including representatives from the following institutions and organizations:

- Ministry of Public Health (*Ministère de la Santé Publique et de la Population*, MSPP)
- USAID/Haiti
- National Public Health Laboratory (*Laboratoire National de Santé Publique*, LNSP)
- Division of Epidemiology, Laboratory and Research (*Direction d'Épidémiologie, de Laboratoires, de Recherche,* DELR) of the Ministry of Public Health
- National Anti-Malaria Program (*Programme National de Lutte Contre la Malaria*, PNCM)
- Carrefour Community Health Office
- Carrefour Maternity Hospital
- Cabaret Municipal Hospital

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 Haiti

Haiti is located in the Caribbean Sea, where it shares the island of Hispaniola with the Dominican Republic, and is approximately 700 miles from the Unites States. The country is 10,714 mi² and has a total population of 10,711,000 inhabitants (est. 2015), approximately 57 percent of which is urban[4]. The risk of Zika virus is relatively unknown, due to limitations in access to confirmatory health and laboratory services. Yet it is suspected to be high and in line with the prevalence of other arboviral diseases in recent years, namely dengue and chikungunya.

In most people, Zika is a relatively minor disease with mild-flu like symptoms or no symptoms at all. In a few cases, complications such as Guillain-Barré syndrome have occurred. With general symptoms very similar to dengue and chikungunya, two other urban arboviral infections common in the region, Zika diagnosis is unreliable without laboratory confirmation. Both diseases are widespread throughout much of the Western Hemisphere (i.e. the Caribbean, Mexico, and Central and South America), and numerous epidemics—all four serotypes of dengue plus chikungunya—have been documented in Haiti.

The Zika virus was first confirmed in Haiti in early 2016. Confirmation of autochthonous transmission was based on two sets of samples. In January 2016, 11 sera were submitted by a private clinic to the Caribbean Public Health Agency (CARPHA) for testing by reverse transcription polymerase chain reaction (RT-PCR); of these, five (45%) were Zika positive and the remaining, non-positive six also did not test positive for dengue or chikungunya viruses. In epidemiological weeks 1-21 of 2016, 154 sera were tested by the LNSP, of which 16 (10%) were positive for Zika.

In addition to lab-confirmed cases, the DELR of the Ministry of Public Health uses the World Health Organization (WHO) case definition[5] of "Rash and/or fever with at least one of the following signs or symptoms: Arthralgia, Arthritis, and Conjunctivitis (non-purulent/hyperemic)" to determine suspected cases based on clinical description. In the period from October 11, 2015 to May 28, 2016, the DELR recorded 2,349 suspected Zika cases. These cases are disaggregated by department and ranked from highest to lowest population according to official government estimates in Table 1.[6]

Table 1: Presumptive Cases of Zika Infection in Haiti, per Department, Ranked by Population

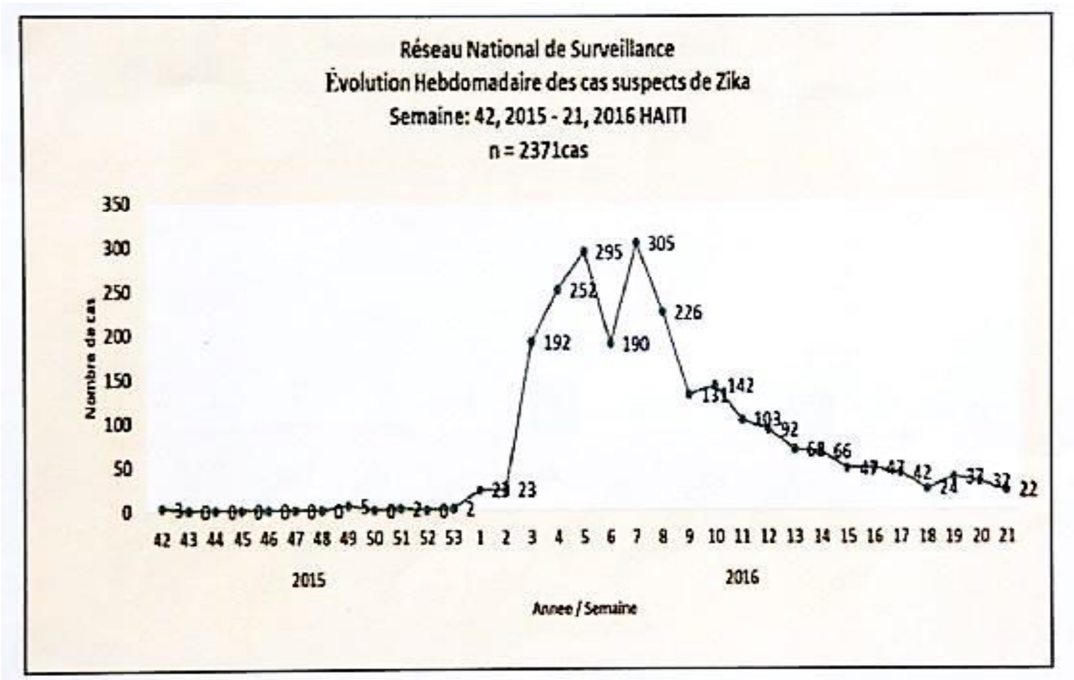
Département	Capital	Population (millions)	Cases	% of total
Ouest	Port-au-Prince	4.03	897	38.0
Artibonite	Gonaïves	1.73	269	11.4
Nord	Cap-Haïtien	1.07	477	20.5
Sud	Les Cayes	0.77	68	2.9
Centre	Hinche	0.75	267	11.3
Nord-Ouest	Port-de-Paix	0.73	37	1.6
Sud-Est	Jacmel	0.63	85	3.6
Grand'Anse	Jérémie	0.47	52	2.3
Nord-Est	Fort-Liberté	0.39	79	3.3
Nippes	Miragoâne	0.34	118	5.0
	Total	**10.91**	**2349**	**99.9**

[4] Encyclopaedia Britannica. August 2013. Haiti. https://www.britannica.com/place/Haiti. Accessed 22 August 2016.
[5] http://www.who.int/csr/disease/zika/case-definition/en/
[6] Government of Haiti, National Disease Surveillance Network, adapted from unpublished data.

Of the 2,349 suspected Zika cases, 1,643 (70 percent) were reported from the three most populous departments, which constitute 63 percent of the total population of Haiti – Ouest, Artibonite, and Nord. This high burden of disease likely reflects the size and concentration of population in these departments as well as the urban nature of Zika transmission. Poorer quality of reporting from the less populated, more rural regions of the country may further skew the perceived burden toward urban locales.

In a graph presented by the DELR (see Figure 1), the first two suspected cases of Zika were recorded in epidemiological week 1 of 2016. In the five weeks that followed, the incidence increased abruptly to a peak of around 300 cases, after which (starting in week 8) there was a steady decline to 22 cases in week 21.

FIGURE 1. SUSPECTED CASES OF ZIKA VIRUS IN HAITI, FROM WEEK 42 IN 2015–WEEK 20 IN 2016



So little is known of Zika epidemiology, that prognosis of future transmission invokes comparison with dengue, a closely related virus transmitted by the same vectors. In the Greater Antilles, dengue transmission is invariably lowest in the cooler, drier months, roughly January to mid-May, later rising to a peak in mid- to late October. The sudden peak of Zika cases in Haiti in January is thus uncharacteristic, as transmission would be expected to be highest in the rainy, warmer season. A plausible explanation of this apparent anomaly is that the force of transmission (i.e. the number of cases generated by each case) was high enough for epidemic transmission in this season, but was later suppressed by progressively colder, drier conditions. With this interpretation, a far higher incidence of disease could be anticipated in August with a peak in September/October. However, as of late August, transmission continued to decline.[7]

[7] http://digepisalud.gob.do/docs/Boletines%20epidemiológicos/Boletines%20semanales/2016/Bolet%C3%ADn%20Semanal%2031-2016.pdf

Sixty-four percent of the presumptive Zika cases (1,503) occurred in women, perhaps a consequence of heightened concern for birth defects, and thus increased health-seeking behavior. Of these, nine (0.6%) reported being pregnant at the time of their symptoms. The crude birth rate (estimated annual number of births per 1,000 population) for Haiti is 22.83,[8] thus the true number of suspected cases that were pregnant may have been about six times this rate (2349/1000 * 22.83 = 53.62). Of the nine women reported pregnant, one was in her first trimester, four in their second, and four in their third. Of these, eight were aged 29-35 (the age of the ninth was uncertain). Ignoring the sparseness of the data, there are 6.83 million people in the three most populous departments, and 3.4 million are women. Of these, an estimated 22,830 (22.83 * 10^3) will be pregnant during the year, i.e., there will be 9,219 (22,830 * 21/52) pregnancies during the reporting period.

All four dengue serotypes and chikungunya are transmitted throughout Latin America except mainland Chile. The viruses have an endemo-epidemic pattern in the Americas with outbreaks every three to five years.[9] Epidemics can affect tens of thousands of people, after which there may be years of relatively low transmission, probably limited by herd immunity. Epidemics of dengue are more frequent than those of chikungunya because there is essentially no cross-immunity to individual serotypes. Introduction of new dengue serotypes can result in widespread dissemination throughout the region. Chikungunya is a relatively recent introduction, first reported in early 2014.[10] An interesting feature of its initial spread in the Caribbean islands was that it was restricted to Francophone countries (starting on the small island of Saint Martin). This is a reflection of the mode of dispersal of the virus in travelers. Occasional autochthonous cases of dengue occur at sites along the Gulf of Mexico, especially Florida.

If the epidemiologic pattern of dengue and chikungunya is accepted as a proxy for Zika, then it is reasonable that the largest number of cases of Zika will occur in the 2016-2017 period. To combat this, it is recommended that an immediate campaign to help prevent new infections during this critical period should be combined with enhanced vector control initiatives.

2.2 Vectors of Arboviral Diseases and their Distribution in Haiti

Aedes aegypti is widely considered the principal vector of Zika in the Americas. A second species, *Aedes albopictus,* is regarded as a secondary vector given its tendency to bite vertebrates other than humans.[11] In their original habitat, both species used small, natural pools—tree-holes, plant axils, fruit husks, and rock-holes—to breed.[12] They have since adopted the human peridomestic environment, able to breed in most any hollow vessel.[13] Densely populated urban settings with limited waste management capacity, as found in large, developing tropic cities, thus provide an environment conducive to elevated populations of *Aedes* mosquitoes and occurrences of arboviral epidemics.

Aedes aegypti and *Aedes albopictus* are the principal vectors of human arboviral diseases such as dengue and chikungunya worldwide and *Aedes aegypti* is likely ubiquitous in most urban areas in Haiti. The same is true for *Aedes albopictus*, and certainly is for neighboring Dominican Republic. Both species may be present in the same areas, yet *Aedes albopictus* tends to be more prevalent in the presence of vegetation.

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[8] http://www.indexmundi.com/Haïti/birth_rate.html

[9] Dick et al. 2012. History of Dengue Outbreaks in the Americas. Am J Trop Med Hyg. 2012 Oct 3; 87(4): 584–593 http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3516305/

[10] http://www.pih.org/blog/mosquito-borne-virus-sickening-thousands-in-haiti

[11] Many closely-related Aedes species, i.e., *Aedes bahamensis* and Aedes mediovitatus are competent to transmit (and become infected by the virus) but are unlikely to have any significant role in transmission.

[12] Reiter, P. (2016). Control of Urban Zika Vectors: Should We Return to the Successful PAHO/WHO Strategy? *PLoS Neglected Tropical Diseases*, *10*(6), e0004769. http://doi.org/10.1371/journal.pntd.0004769

[13] Ibid

Thus, in many parts of the world, *Aedes aegypti* is an inner-city species whereas *Aedes albopictus* favors the periurban environment and, due to its non-host-specific feeding behavior, can breed away from human habitation. In Europe, *Aedes albopictus* is present to around 4,000 ft. in tiny, isolated villages in the Albanian Highlands (in regions where snow can be present on the ground in June) and *Aedes aegypti* is present to more than 7,000 ft. in Colombia. It is thus fair to assume that there is no altitudinal limit to either species in Haiti.

2.3 Vector Control Interventions in Haiti

Haiti's vector control operation is conducted by twelve entomological monitoring and vector control units referred to as brigades. Each of the 10 departments has a brigade composed of four field workers and a supervisor; there are two additional brigades for the metropolitan area surrounding Port-au-Prince. The brigades do not fall under a national framework for arbovirus control, and generally work in an ad hoc fashion, their target locations based on local epidemiology reports. On this scale, it is unlikely they can have a significant impact on arbovirus vector populations or virus transmission, except perhaps on a short-term and highly localized level.

In Carrefour, a city contiguous to Port-au-Prince with a population of approximately 500,000, a Sanitary Officer at the Office of Community Sanitation (MSPP) was interviewed regarding a mosquito survey recently completed near the office. The survey reported that 260 putative breeding sites were found, yet there was no attempt thereafter at mosquito control. The officer had no microscope or identification key to distinguish the species found in the breeding sites, and he was also responsible for several other activities, including dog control for rabies prevention and filariasis reduction.

3. FINDINGS

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

3.1.1 National Level

In Haiti, entomological monitoring and vector control activities are conducted within a centralized structure under the National Anti-Malaria Program (*Programme National de Lutte Contre la Malaria,* PNCM), directed by Dr. Jean Frantz Lemoine. The PNCM operates within the MSPP, with links to the *Direction d'Organisation des Services de Santé* (DOSS) (Directorate of Health Services Organization) and DELR, as well as external entities such as agencies of the United States Government. A complete organogram of PNCM's structural relationships was unavailable at the time of the assessment. The PNCM does not directly manage the twelve entomological monitoring and vector control brigades at the subnational level.

PNCM resources are mainly drawn from external sources, the vast majority of which are directed toward the eradication of malaria, focusing on parasite detection and treatment. Resources targeted for vector management are used for control activities rather than entomological surveillance. Budgetary details were not provided to determine the exact figures allocated for vector control activities. The Global Fund provides primary funding for the brigades for both malaria eradication and tuberculosis control activities. The Global Fund does not, however, hire staff or use existing staff for non-malaria vector control activities. USAID funds the brigades' lymphatic filariasis elimination activities, and the United States Centers for Disease Control and Prevention (CDC) provides additional resources for cholera control. PNCM performs vector control activities against *Aedes aegypti*, yet these activities are conducted in an ad hoc manner. At present, there is no designated funding for the arboviral diseases transmitted by *Aedes* species.

There appears to be good coordination between health care providers relating to various notifiable diseases, including Zika. There is an excellent central database system for notifiable diseases, run and maintained by the DELR and accessible by computer at the district clinics. Data are analyzed, mapped, and disseminated by DELR to all stakeholders via weekly, web-based Communicable Disease meetings.

The DELR system does not include data relating to surveillance and control of arboviral vectors; these are either stored on paper or input into local computers.

The LNSP does have the capability to perform insecticide resistance tests using the CDC bottle bioassay technique, and these data should be available to inform the brigades as to suitable insecticides for use against *Aedes* mosquitoes. Although the technique is available, no resistance testing data were provided to the evaluation team.

3.1.2 Subnational Level

The five-person brigades, composed of four field workers and a field supervisor, are responsible for all vector-borne diseases, yet their duties are not restricted solely to vector control. As mentioned above, the brigades receive funding from the Global fund for malaria and TB, from USAID for lymphatic filariasis, and from CDC for cholera control.

Brigade field supervisors are tasked with serving as the link between field workers and the central PNCM for planning, management, and reporting purposes. However, brigades are largely autonomous and plan their work based on the epidemiological data received from the local district clinics without input from the central PNCM. This lack of oversight may contribute to infrequent and narrow control efforts against *Aedes aegypti* that are unlikely to have much of an effect on either the vector or the arboviruses it transmits.

Vector control methods used by the brigades include small-scale, hand-held thermal fogging, truck-mounted ultra-low volume (ULV) and direct application of larvicides (Bti or temephos) into containers harboring larvae. Malathion is also used to target adult mosquitoes through truck-mounted ULV. These applications are generally reactive and are not implemented according to a well-defined schedule. Without surveillance of *Aedes* mosquitoes in country, it is not possible to evaluate the effect of control measures, and to inform and direct future applications. The same applies to the possibility of investigating new novel mosquito control methods. There is insufficient human resource capacity to carry out surveillance and research activities, and the assessment team did not identify other viable partners to fill the resource gap.

At the department level, communication between health departments in relation to notifiable diseases and their clinical diagnosis occurs through in-person malaria case collection. Someone is sent to health posts and clinics on a motorcycle to collect data. Data are then entered into a central database system and then analyzed and disseminated by DELR at the weekly Communicable Disease meetings. Unfortunately, a similar system is not available for vector control activities. There is no central database for reporting surveillance and control efforts.

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

3.2.1 National Level

At present, there is no national-level steering committee or technical working group assigned to vector surveillance and control, although a Vector-Borne Disease Working Group comprised of NGOs, CDC, and UNICEF existed in 2010.[14] The only visible community engagement efforts, such as community clean-up projects, are steered by non-government agencies such as the Haitian Mosquito Control Association.[15] However, these efforts are minimal and do not appear to demonstrate much impact on local vector populations.

Posters with behavior change communication (BCC) messages are displayed on the walls of clinics and government buildings. These posters encourage home-based prevention of Zika through waste management, covering of water storage containers, and sleeping under mosquito nets, as well as encouragement for individuals to seek a health facility if they think they may have Zika. Other posters provide more details about how Zika is transmitted (see Figure 2 for poster examples).[16] Haiti's adult

[14] Albert, Michael <michael@mentor-initiative.net> Vector Borne Disease Working Group Update. https://groups.google.com/forum/#!topic/wash-response-haiti-2010/28oTVIN5yLI. March 2010. Accessed 23 August 2016.
[15] Jules, Morel. 2014. Haiti after the 2010 earthquake: Mosquito education and a meal help make a difference. Wing Beats 25(3).
[16] http://mspp.gouv.ht/newsite/wp-content/uploads/2016/08/Affiche-Zika-1-230216.pdf
http://mspp.gouv.ht/newsite/wp-content/uploads/2016/08/Affiche-Zika-2-230216.pdf

literacy rate from 2008-2012 was estimated at 48.7 percent,[17] thus presenting potential challenges in comprehension of poster content among those at risk.

FIGURE 2: MOH ZIKA-RELATED IEC AND BCC MATERIALS

Information, education and communication (IEC) handout materials were found at subnational level, but related only to lymphatic filariasis.

3.2.2 Subnational Level

BCC posters and other materials were not visible at any of the district clinics visited. As at the national level, the only IEC materials available were tri-fold brochures on lymphatic filariasis.

Brigades address public meetings to explain the role of mosquitoes in Zika transmission and promote the importance of source reduction and other Zika protection strategies. Educating the community on the mosquito life cycle, including their breeding habits, and influencing behavior change to prevent Zika is a far more complex challenge than merely providing people with factual information. Haiti's brigades are aware that communication is needed to combat Zika and prevent and minimize further transmission. A well-developed BCC/IEC campaign strategy beyond printed materials should be developed for Zika and other arboviruses transmitted by *Aedes* mosquitoes.

As mentioned above, local campaigns to promote source reduction have been launched by the Haitian Mosquito Control Association and other NGOs. Although the assessment team undertook short visits outside Port-au-Prince, additional information on NGOs and other local groups was not readily available at the time of the assessment.

[17] UNICEF, 2013. At a glance: Haiti Statistics. http://www.unicef.org/infobycountry/haiti_statistics.html. Accessed 23 August 2016.

3.3 Human Resources

3.3.1 National Level

Despite the presence of enthusiastic and motivated staff, human resources (HR) available to the PNCM is limited. Although the remit of PNCM is to control and prevent malaria and filariasis, it is not specifically tasked with controlling the container-breeding mosquitoes that transmit dengue, chikungunya, and Zika, namely, *Aedes aegypti* and *Aedes albopictus*. The majority of the funding provided to PNCM comes from the Global Fund and is specifically intended for malaria control. Control efforts against *Aedes aegypti* are conducted on an ad hoc basis when the spread of dengue, chikungunya, or Zika is deemed sufficiently serious. On those occasions, PNCM is diverted from its primary vector control activities against *Anopheles albimanus* (primary malaria vector) and *Culex quinquefasciatus* (primary filariasis vector).

At the highest level of planning and producing guidelines for the control of arbovirus transmitting mosquitoes, there are currently only two entomologist positions in the PNCM. One of these positions is vacant and the sole entomologist in the PNCM is on sick leave and due to retire soon. The primary role of these entomologists is malaria control. There is currently no qualified entomologist available to develop and coordinate a national vector control plan for *Aedes,* nor to develop entomological surveillance and environmental compliance activities. Consequently, no data are available for *Aedes* mapping and vector control planning.

Mapping of the transmission risk from the various arboviral diseases is inadequate and based entirely on the epidemiology of clinically-diagnosed cases. The data are restricted to the department level and are of minimal use for the planning and implementation of vector control operations. Due to the lack of vector monitoring activities there are no data available on arboviral vector abundance.

The DELR has qualified GIS technicians capable of analyzing epidemiological and vector distribution data but the lack of data coming in from the field limits the level of detail in the maps produced. If reliable entomological surveillance and control data were available, the DELR does have the human and other resources to provide good data analysis, mapping, and dissemination of the data to relevant government departments and stakeholders.

The insectary located at the LNSP has two laboratory technicians trained at the University of Florida and competent to perform the basic functions required within an entomological laboratory. This includes the ability to identify the adult and larval stages of the primary and secondary vectors of the various arboviruses and maintain insectary colonies of various mosquito strains. The technicians have also been trained to conduct larval and adult bioassays to detect chemical resistance using the CDC bottle bioassay technique. There was no indication that experience conducting WHO tube tests should be included as part of training for brigade members. More advanced functions of an entomological laboratory such as the ability to detect chemical resistance levels by molecular analysis (PCR) or by enzyme assay are not available, but could be with the correct training and equipment. Due to the location of the insectary/entomology laboratory within the same compound as the LNSP and PNCM, the dissemination of information such as bioassay results to the relevant stakeholders should be easy.

Research-oriented entomological studies, such as the determination of a given mosquito species' capacity to transmit a specific disease pathogen, are beyond the scope of the laboratory technicians. To carry out research projects, such as the determination of vector competence or disease infection thresholds for human infection, would require the collaboration and facilities of external research departments such as the University of Florida or CDC. Training has, in the past, been performed by various external organizations, as with the two insectary staff trained by the University of Florida.

3.3.2 Subnational Level

At the department level, public and private health clinics are the first points of contact for patients with suspected vector-borne diseases. These clinics are able to diagnose malaria cases using a rapid test kit. Conversely, diagnosis of the arboviral diseases transmitted by *Aedes aegypti* is made purely on the patient presenting symptoms consistent with the case definition of the disease. Information from these clinics is entered into a centralized database system and immediately available for analysis and dissemination by the DELR.

As discussed previously, the front-line vector control functions of the PNCM are carried out at the subnational level by the twelve brigades comprised of small, five-worker units (60 staff in total). This equates to one person performing mosquito control activities per 180,000 people. Although the responsibilities of these brigades are the official charge of the central office of the PNCM, their activities appear to be directed from the clinical diagnosis of diseases made at the department level. In addition, the focus of control operations is directed toward the control of malaria vectors, field diagnosis of infection, the control of filariasis vectors, and public education about malaria and tuberculosis. It is only in response to a major outbreak of dengue, chikungunya, or Zika that control efforts would be made against *Aedes aegypti*. The responsibility and duties of these brigades, in terms of both population and specific disease control, are well beyond the capacity of twelve brigades. As a result, minimal control is being carried out at the department level against the vectors of Zika.

With basic training, all brigade members would likely be able to collect, preserve, and label larval samples to send to the central entomology lab. Brigade members have varying levels of skill regarding field identification of adults and larvae, and refresher training in species identification is recommended. The limiting factor that would prevent this type of work is the workload that the brigades already have. More advanced techniques such as mapping vector abundance, seasonality, preferred breeding sites, and community-wide larval surveys could also be implemented with basic training, provided more brigade members were hired. It is unlikely that training in advanced techniques such as determination of parity rates, insecticide susceptibility testing, evaluations of control interventions (chemical, biological or physical), and monitoring changes in vector behavior could be offered, unless more entomologists or highly-trained staff are hired at the district level.

3.4 Infrastructure

3.4.1 Presence of Reference Laboratory at the National Level

The national public health laboratory, the LNSP, is a modern facility constructed in 2007 in the DELR compound. The laboratory is part of the MSPP and is directed by General Manager Dr. Jacques Boncy. The LNSP is responsible for supervision and coordination of regional laboratories and provides training for laboratory technicians throughout the country. The laboratory is well-equipped for routine serology, virology and molecular diagnostics, including dengue, chikungunya, Zika, West Nile and other arboviruses.

In conjunction with DELR and WHO, the LNSP participates in field studies of the prevalence of infectious disease and investigates outbreaks of malaria, dengue, chikungunya, and Zika. The LSNP also provides training for laboratory technicians in all 10 departments of the country. Dr. Boncy expressed a desire to strengthen links and partnerships with external organizations such as the University of Florida, CDC, and the Pan American Health Organization (PAHO).

3.4.2 Functional Insectary

Since September 2014, there has been a 12m shipping container, equipped as an insectary, installed on the DELR compound. The insectary itself is a modified, three-room container, designed with assistance from the University of Florida. There is a room for mosquito species identification, equipped with two MEIJI stereo microscopes and an external light source; an adult mosquito holding chamber with air conditioning and humidifier; and a larval mosquito room for rearing mosquitoes. The facility is adequate for routine susceptibility tests and similar functions, although the room for adult insects is somewhat small.

The laboratory is maintained by two University of Florida-trained technicians. The technicians have been trained in adult and larval identification and in the CDC bottle bioassay technique for determining insecticide resistance levels. Both technicians were absent during the site visit and there was no established colony of any mosquito species, although a few small cages containing *Culex quinquefasciatus* males were present. Likewise, the larval mosquito room had only a single tray of larvae containing 20-50 *Aedes aegypti* larvae.

No membrane feeding apparatus appeared to be present in the insectary, which would make the maintenance of permanent colonies of mosquito species very difficult. Membrane feeding apparatus or laboratory animals (if ethically permitted) would need to be provided. The section of the insectary serving as the adult mosquito holding chamber was very small and only suitable for holding a small number (<10) of $32cm^3$ cages.

3.4.3 Transportation and Equipment

Although equipment was not examined, the brigades reportedly use hand-held thermal fogging, truck-mounted ultra-low volume (ULV) and direct application of larvicides (Bti or temephos) into containers harboring larvae. Malathion is used to target adult mosquitoes through truck-mounted ULV. The status of equipment availability, maintenance, and suitability at both national and regional level remains unclear.

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

3.5.1 National Level

There appears to be no capacity to design and prepare an entomological monitoring or vector control plan against *Aedes aegypti* or *Aedes albopictus* due to lack of qualified entomologists at the national and department levels (as discussed in sections 3.3.1 and 3.3.2). This is further complicated by lack of data on historic insecticide usage (both agriculture and public health), the use of domestic insecticides, and the historic status and trends of insecticide resistance status. There is limited published material available on the types of vector control that have been used.[18] Epidemiological data, based on clinical diagnosis, indicates seasonal increases in suspected cases of Zika. However, data from vector monitoring activities are essential for planning a robust vector control program.

[18] Krogstad, D.J., V.R. Joseph, L.H. Newton. 1975. A prospective study of the effects of ultralow volume (ULV) aerial application of malathion on epidemic Plasmodium falciparum malaria. IV. Epidemiologic aspects. *Am J Trop Med Hyg* 24(2): 199-205.

3.5.2 Subnational Level

At the department level, vector control activities are conducted by the five-person brigade in response to the identification of suspected clinical cases of arboviral *Aedes*-spread diseases in district clinics. No entomological monitoring/surveillance activities are planned or performed.

3.6 Implementation Capacity

3.6.1 National Level

Even if an entomological monitoring and vector control plan could be developed, its implementation would be challenged by the lack of qualified entomologists at the national level and operational field workers at the subnational level. With assistance from external organizations, such as University of Florida, CDC, or others, specific projects to answer targeted entomological questions could be implemented. This could include fixed duration studies looking at parity rates, vector resting behavior, chemical resistance status and mechanisms, biological control, and/or novel control techniques.

Demonstrated capacity in IEC and BCC was limited to posters promoting home-based prevention and encouraging individuals to visit a health center if they present Zika symptoms. Overall, the PNCM currently lacks capacity to direct the implementation of long-term activities such as vector surveillance, chemical and physical control activities, community education, and source reduction. Moreover, the twelve brigades do not have the capacity to implement these activities at the subnational level.

3.6.2 Subnational Level

Outdoor space-sprays ("fogging") are widely used for *Aedes* control, particularly in response to outbreaks of disease. The impact of such treatments is temporary, because they are only active in the short time that the aerosol remains airborne and probably only when the target insect is in flight. The dosages used, measured in ounces per acre (ml/hectare), are too low to affect the aquatic stages, so emergence of adults is not interrupted by the treatment. There is little evidence of the efficacy of fogging in the urban environment and, from an epidemiological standpoint, it is unlikely to have a significant impact on transmission, except perhaps *after* the peak of epidemic transmission.

Brigades record vector control data on paper and possibly local computers. However, they have little training and equipment, and no established program in vector control. As outlined above (section 3.6.1), the implementation of any additional vector management activities would require hiring field workers at the subnational dedicated to surveillance and control of arboviruses. In addition to human resources, any increase in vector control activities would require additional equipment such as vehicles, fuel, insecticides, materials for community engagement, and data management capabilities.

Community mobilization is unlikely to be effective without a national educational campaign to address the low perceived danger of Zika compared to the risk of cholera, typhoid, and malaria. Furthermore, the lack of refuse collection and potable water supply would make community clean-up operations extremely difficult. While epidemiological data based on clinical diagnosis could be used to show seasonal increases in suspected cases of Zika, the ability to take action based on this data is negligible.

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

There is a centralized database system used by district clinics to input clinical data for analysis by the DELR. A similar system could be applied to vector surveillance, vector control data, and environmental compliance if reliable field data could be collected. To achieve good field data, rigorous supervision and careful recording of data is needed. The main concern for a central database would be the quality and usefulness of the data being collected, as data need to be comprehensive enough to inform and direct Zika vector control activities. Unfortunately, data of such quality are not available and cannot be obtained without employing many field workers as part of a dedicated program against *Aedes aegypti* and *Aedes albopictus*. Establishing suitable data recording systems would be an important component to consider when developing national capacity.

3.7.2 Capacity to Analyze and Interpret Data

The DELR has solid capacity and facilities with which to analyze and interpret epidemiological data, and to generate good-quality maps with spatial data. The DELR also has qualified GIS technicians capable of analyzing epidemiological and vector distribution data, if the data were available from the field. The PNCM would be able to assist with the analysis of entomological data, if it had entomologists trained in the use of GIS software. The DELR does not currently receive data recorded by the brigades relating to vector surveillance and control activities.

3.7.3 Capacity to Produce High Quality Reports

As discussed above, the shortage of field workers to produce field data, a centralized database, and an entomologist to do the analysis prevent the production of high-quality summary reports at the higher levels of the health system.

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

3.8.1 National Level

There appears to be a lack of a functional inter-sectorial coordination mechanism in Haiti for vector control. The MSPP has no department or resources dedicated to arboviral vector control. There are no arrangements in place to liaise with stakeholders in the design and planning of anti-Zika initiatives. Likewise, there is no systematic mechanism to educate or engage communities in activities aimed at reducing the abundance of these vector mosquitoes in their environment, such as community clean-up projects.

There are valuable links to external organizations such as the University of Florida and CDC. Both have made considerable contributions toward training and infrastructure, and are developing training and other programs to tackle the Zika. The large number of aid organizations and NGOs involved in funding various public health projects in Haiti show that financial assistance and technical support are available; however, for this support to be useful to Zika control it needs to be part of a clearly planned program with specific objectives.

3.8.2 Subnational Level

The only stakeholder engagement and vector control activities carried out are implemented by the brigades in each department (on top of their other responsibilities). All stakeholders interviewed were aware of the challenges they face and the opportunities' available in vector control. Dr. Paul Adrien at the DELR runs a full training program for epidemiologists; however, shortage of funds thwarts plans to hire these students who have completed the course. Dr. Lemoine of the PNCM commented that, although there are only 60 brigade members to provide malaria surveillance and vector control activities for the whole of Haiti, the Global Fund, which provides the majority of PNCM funding, will not support the hiring of either additional staff or the use of existing staff for non-malaria vector control activities.

3.9 Insecticide Registration Status and Environmental Compliance

3.9.1 National Level

It is unclear which Government of Haiti entity was responsible for insecticide registration and environmental compliance. An online report from 2010 states that the Ministry of Agriculture, Natural Resources and Rural Development (MARNDR) is responsible for regulation of pesticide import, distribution, use, and disposal. The 2010 USAID/Haiti Mission-Wide Pesticide Evaluation Report and Safer Use Action Plan (PERSUAP) stated that Haiti does not have functional legislation governing pesticide import, distribution, or use. The report found products were imported from the United States, South and Central America, Europe, and China. Some labels follow the WHO-recommended color toxicity coding system and many do not. Labels and safety information were in English, Spanish, and Chinese, but rarely in French and never in Haitian Creole. Some retail stores remove products from original containers and sell them in smaller plastic containers or brown paper bags. There was no evidence of a suitable facility for waste management and disposal of insecticides.

3.9.2 Subnational Level

There is limited availability of personal protective equipment (PPE) and its use appears to be infrequent based on interviews with members of the brigades. No additional data was available at the department level, therefore questions remain on issues such as environmental compliance in relation to the use, storage, and disposal of insecticides.

4. KEY ISSUES AND CHALLENGES

For many decades, Haiti has endured a complex convergence of political and social issues, poverty, and natural disasters, which has resulted in stalled progress against health and other development benchmarks. Among Haiti's chronic problems that exacerbate threats such as Zika, are water-borne diseases, poor nutrition, inadequate health services, and deficient water and sanitation systems. Deaths in childbirth and infant deaths rank in the fourth quartile of global tallies, adjacent to countries such as Djibouti, Yemen, Togo, and Burkina Faso. Haiti has the lowest level of access to drinking water and basic sanitation in the Western Hemisphere, and a quarter of infants under the age of five suffer from chronic malnutrition.

Against this background, there are significant issues and challenges related to the country's capacity for entomological surveillance and vector control:

1. The Zika epidemic is climbing in the region, and data trends suggest that Zika incidence and prevalence may climb further.[19] Using the frequency of dengue and chikungunya epidemics as a proxy, transmission in 2017-2018 will likely be low, with no major outbreaks expected to occur for many years. However, given the uncertainty, Haiti must balance minimizing the immediate impact of infections in 2016, with creating more sustainable structures that will permit the country to more effectively respond to similar outbreaks in the future.
2. There is currently no national body to coordinate, plan, and finance a widespread and sustained vector control effort to suppress Zika transmission. Yet, given the scant body of evidence on Zika and on the levels of insecticide resistance among vectors in Haiti, the impact of Zika control measures is difficult to predict.
3. The country's existing vector surveillance and control workforce is inadequately staffed with only 12 brigades of five personnel each assigned for the entire country. Relative to the population, this is a ratio of 1 to 180,000. In addition, the brigades lack training, equipment, and guidance from an established vector control program, and have multiple other responsibilities entirely unrelated to vector control.
4. There is no sizeable program for surveillance or control of Zika vectors in the country, nor is there a central database for reporting surveillance and vector control efforts.
5. Weak infrastructure for waste management and water supply make households susceptible to mosquito breeding via shallow containers and uncovered water storage vessels. This suggests an imperative for environment-centered treatment strategies.
6. Women of reproductive age and pregnant women in particular are a high-risk population. Reaching them with behavior change communication (BCC) and information, education and communication (IEC) activities is challenged by low levels of antenatal care coverage.

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[19] At the time of submission, an article entitled "Model-based projections of Zika virus infections in childbearing women in the Americas" (Perkins et al.) has appeared in *Nature Microbiology* and suggests that "…1.65 (1.45–2.06) million childbearing women and 93.4 (81.6–117.1) million people in total could become infected in the Americas before the first wave of the epidemic concludes."

5. RECOMMENDATIONS

5.1 Recommendations to the Government of Haiti

1. **Establish national-level steering committee or vector control technical working group**, potentially building on the Vector-Borne Disease Working Group comprised of NGOs, CDC, and UNICEF. Stakeholders should include Haitian government entities, other donors and implementing partners, as well as community-based organizations to enhance their involvement and impact on vector control.

2. **Implement short-term response measures to maximize protection of those most at risk.** Given the current state of Zika circulation in the region and its presence in Haiti, there is a pressing need to limit its spread through support of vector control activities, distribution and use of personal repellants, and dissemination of Zika-related BCC messages. The response in Haiti should specifically target the Ouest, Artibonite, and Nord departments, where 63 percent of the population and 70 percent of putative cases exist. Where possible, intervention efforts should focus on pregnant women or women of childbearing age as they represent the most at-risk segment of the population.

    a. **Vector control activities:** Consider initiation of a targeted or pilot treatment with a residual insecticide. If implemented, this would necessitate a significant expansion of the current spray workforce, thus requiring creative mechanisms to recruit a sufficient number of sprayers. One option could be to mobilize the military. Control activities could be implemented in line with the following guidelines:

    - Avoid large-scale chemical applications. Given the unknown status of insecticide resistance among Zika vectors in Haiti, it is inadvisable to conduct large-scale applications. Before commencing even with a targeted treatment, whether via residual insecticide or any other application, it is critical to obtain a better understanding of the resistance dynamics of local mosquito populations. Without updated resistance data, such applications may cause unnecessary exposure to pesticides by both workers and the general public.

    - Once the most appropriate insecticide and formulation is identified, a residual insecticide could be applied to surfaces where mosquitoes are likely to rest. Target locations could include sites where people, especially women, are likely to encounter infected insects, such as maternity clinics, hospitals, schools, markets, and churches. Treatments might also be administered in and around the homes of suspected Zika cases.

    - Spray teams would search for breeding sites to a defined radius around the abovementioned sites. These sites and their surroundings would be treated up to a specific radius with the insecticide.

    - A residual insecticide worthy of exploration is Suspend-Polyzone®. It is a long-lasting polymer-enhanced formulation that, when sprayed on solid surfaces, forms a stable, UV-opaque, rainproof deposit. The active ingredient is deltamethrin, an insecticide widely used for insect control and approved for mosquito control by the WHO, CDC, and European Commission. The manufacturer claims that the treatment can remain effective outdoors for at least three months.[20] The WHO approves its use for Indoor Residual Spray with an expected efficacy of six months.[21]

b. **Distribution and Use of Personal Repellants:** Women, and in particular those that are pregnant, should use personal repellants designed to protect against *Aedes aegypti* and approved for skin application during pregnancy. DEET, for example, meets both of these criteria. To maximize the knowledge of, access to, and use of such repellants, the following is recommended:

- Set up a network of mosquito repellent distribution points that includes antenatal clinics, among other locations. Women of childbearing age should be made aware of these distribution points.
- Provide instructions on the frequency and method of repellant application in the form of IEC materials and/or from knowledgeable individuals at distribution points. Among pregnant women, use of repellants would be advised, at a minimum, from the second to the fourth month of pregnancy; the risk of microcephaly is thought to be highest during the third month. Repellant should be applied at least twice a day, when *Aedes aegypti* are most active (i.e. morning and mid- to late afternoon), and on preferred *Aedes aegypti* biting sites (i.e. legs and ankles). Consideration should also be given to using insecticide-impregnated papers that release insecticide when they are burned.

c. **BCC Messaging:** Develop and launch a countrywide BCC/IEC program to limit Zika transmission and its effect on Haitians. A campaign of this nature should be designed by experts in BCC, with targeted messaging to help minimize the risk of transmission. Illustrative approaches may include:

- Provision of information on the modes of Zika transmission, the risks of infection during pregnancy, and strategies to avoid infection.
- Promotion of source reduction activities, including identification and elimination of breeding sites at the household and community level.
- If appropriate and feasible, women could be encouraged to visit clinical facilities as soon as they suspect they are pregnant.
- Given that sexual transmission of Zika is now well-documented, condoms could be distributed along with verbal or written information on the importance of practicing safe sex (particularly from the second to the fourth month of pregnancy).

3. **Support long-term capacity improvements**: In addition to measures that attempt to limit the effect of Zika in the short-term, it is critical to simultaneously strengthen in-country capacity to respond to Zika and similar outbreaks in the future. The objective of these efforts would be to improve control and surveillance activities against the mosquito vectors of arboviruses, primarily *Aedes aegypti*. Recommendations include:

a. **Develop an eLearning capacity-building program:** As an alternative to sending staff offsite or bringing in specialists to conduct trainings, an eLearning platform could offer a sustainable and cost-effective approach. Specific training topics could focus on equipment and its maintenance, surveillance and vector control methods, and safe storage and use of insecticides. The program could be administered online or via internal network, or delivered via flash drive, depending on the availability of resources of target audiences. A certification

[20] https://www.backedbybayer.com/pest-management/general-insect-control/suspend-polyzone.
[21] http://apps.who.int/iris/bitstream/10665/90976/1/9789241506304_eng.pdf

exam could be included at the end of each topic to ensure required standard are met. The program could be made available to all countries in the region and hosted by PAHO, or developed in collaboration with regional authorities from the start.

b. **Strengthen information systems:** While Haiti has an adequate system in place for the dissemination of epidemiological data, the capacity for the capture, analysis and use of entomological data remains limited. A centralized database should be developed for reporting and monitoring of surveillance and vector control efforts. El Salvador offers a good example – the country has an online, centralized database that facilitates capture and analysis of epidemiological and entomological data, and its subsequent dissemination in weekly bulletins.

c. **Recruit a quality assurance (QA) specialist for vector control:** The presence of a QA specialist in-country to support vector control activities could facilitate more rapid identification of bottlenecks and development of solutions to address them. An example of the need for such a position was seen at the insectary facilities. Despite having trained staff and adequate facilities for maintaining mosquito colonies for resistance testing and intervention evaluations, no colonies were actually being maintained. The QA specialist would:

   - Provide ongoing, on-the-job training to personnel involved in vector control.
   - Support vector control personnel to conduct routine supervisory visits to district units involved in vector control and surveillance activities. The supervisory teams would collaborate with these units to identify weaknesses, establish action plans to address them, and continuously follow up on progress against the plans.
   - Monitor the implementation of vector control activities in the country, and lead assessments to determine the most effective techniques on managing vector populations.

5.2 Recommendations to Donors

Systems-level interventions are essential, given that basic, individual-level prevention efforts of waste disposal and non-storage of water are challenged by the nation's inadequate waste management systems and lack of continuous water supply. Further, *Aedes*-borne viruses are a problem, even in countries where basic sanitation is far better and the incidence of infectious disease is much lower. It is in this context that these recommendations are proposed:

1. Support the recommendations listed above to the government partners by providing funding, in-kind contributions, or technical assistance, and by participating in the to-be-established national steering committee or vector control technical working group.
2. Consider funding for a pilot field trial of a perifocal treatment, similar to that which was successful in the PAHO-coordinated *Aedes aegypti* eradication campaign in the 1950s and 1960s. See Addendum 1 for a description of the pilot. Another option for a pilot that merits consideration is insecticide application in homes via IRS. This has yielded promising results in minimizing dengue vector populations in other parts of the Americas.
3. Invest in long-term capacity improvements in Haiti such as training of brigades, centralized database for reporting and monitoring of surveillance and vector control efforts, and a QA specialist.
4. Consider support for an online training course that could be made available to all countries in the region on PAHO's virtual campus platform [https://www.campusvirtualsp.org/en] or via the Caribbean Public Health Agency (CARPHA).

5. Facilitate regional knowledge sharing. Although language barriers may present limitations, knowledge sharing between countries of the region should be encouraged as a means of exchanging epidemiological trends as well as successful virus prevention and vector control measures. For example, the centralized, online database for epidemiological and entomological data developed in El Salvador could be an asset to other countries in the region, including Haiti.

6. Support research and development of novel approaches to *Aedes* control in the region. The impetus for such research is driven by widespread recognition that current control efforts have not had widespread success. A few options include:

   - Introduction of a transgenic *Aedes aegypti,* created by the company, Oxitec. This genetically modified insect carries a gene that, when transferred from male to female via semen, is lethal to the larvae that hatch from the female's eggs. Field trials in several countries have been promising and several large-scale trials are planned or already underway.

   - Infect mosquitoes with *Wolbachia*, a bacterial, intracellular parasite that may prevent dengue and other viruses from replicating in the mosquito. In theory, the dynamics of the infection are such that once *Wolbachia* is introduced, the bacterium will spread until the entire mosquito population is infected.

   - Conduct rigorous trials of aerial spraying innovations, based on a recent successful experience in Florida (see Addendum 2).

Addendum 1: Pilot Trial of Perifocal Treatments

There have been two notable victories over *Aedes aegypti* in the past: the source-reduction campaigns that began in the Western Hemisphere at the turn of the 20th century, and the *Aedes aegypti* Eradication Campaign—coordinated by PAHO—that followed in the 1950-60s. The goal of the latter was complete eradication of the species from the entire Western Hemisphere and indeed, by 1962, 18 countries had been declared free of the mosquito and of dengue. Unfortunately, for a variety of reasons—including insecticide resistance and failure to sustain efforts in regions where the campaign had been successful—the project was abandoned and both mosquito and virus quickly reemerged.

In the eradication campaign, the principal approach was "perifocal" treatment: field operators searched for infested containers and treated them[22] plus surrounding surfaces to a radius of about 50 cm with DDT. Residual treatments of this kind kill mosquitoes by contact.

The success of the PAHO campaign may be attributable a specific aspect of the behavior of the mosquitoes: female *Aedes aegypti* do not lay "all their eggs in one basket." Instead, they "skip oviposit"—lay a small numbers of eggs (often only a single egg) at many sites. In the field they will lay 60-80 eggs per gonotrophic cycle and thus must visit many sites, thus increasing the likelihood of encountering a treated site. The new formulation of deltamethrin offers promise as a substitute for DDT. A small pilot should be conducted to test its efficacy. The procedure would be simple: ovitraps would be deployed on two successive mornings per week, and the oviposition rate[23] compared in two areas, one treated[24] and one untreated. Ovitrapping would continue until it is evident that the treatment is no longer effective.

Resource Requirements for Pilot Trail of Perifocal Treatments	Cost ($)
Two field workers	?
One road vehicle, preferably a small pick-up truck, gasoline etc.	?
Sixty ovitraps	<50
Germination papers	<100
Two large garbage drums for infusion	ca. $250
Hay or other vegetation for the infusion	Minimal
Hand-pumped portable sprayer	200
Insecticide	Donated

For the purpose of this pilot trial, more information about Port-au-Prince is needed to make an informed selection of suitable sites.

[22] Using a simple hand-pumped sprayer

[23] A simple device for monitoring the egg-laying (oviposition) rate: small black jars ca. 500 ml containing an infusion of hay in water and lined with robust "germination paper." Mosquitoes are attracted to the jars and lay their eggs on the paper. The mean daily count of eggs is a fairly reliable proxy for the numbers of active mosquitoes in the area. http://apps.who.int/iris/bitstream/10665/67047/1/WHO_CDS_CPE_PVC_2001.1.pdf

[24] A prelude would, of course, be confirmation that local strains are susceptible to the insecticide.

Addendum 2: Aerial Spraying:

As discussed in Section 3.6.2, outdoor space-sprays ("fogging") are widely used for *Aedes* control, particular in response to outbreaks of disease. The impact of such treatments is ephemeral—they are only viable in the short time that the aerosol remains airborne and probably only when the target insect is in flight. The dosages used, measured in ounces per acre (ml/hectare), are too low to affect the aquatic stages, so emergence of adults is not interrupted by the treatment. Indeed, there is little evidence of their efficacy in the urban environment and from an epidemiological standpoint; they are unlikely to have any significant impact on transmission, except perhaps *after* the peak of epidemic transmission.

In the current Zika emergency, there has been a call for air-spray to suppress the vector. In Puerto Rico, for example, there is a debate over the issue. In 1987, however, a C-130 transport plane was used to apply Dibrom, an organophosphate insecticide, to the entire urban area of San Juan, Puerto Rico. Although there was an impressive mortality in caged mosquitoes, the wild population—assessed by infusion-baited ovitraps—was unaffected.

Recently, however, three mosquito control agencies in Florida have claimed excellent kill of *Aedes aegypti* by aerial treatments with *larvicides*, Bti (a bacterial insecticide), and methoprene (a juvenile hormone analog that disrupts larval development). Methoprene is probably the most promising because far smaller quantities are required for efficacy. A company with equipment suitable for city-wide application operates for Medfly control in Santo Domingo. Although not immediately viable as a component of a short-term response, a trial of the method is worth pursuing with a longer-term vision in mind.

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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| 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
James Maloney	USAID/Haiti	Senior Monitoring and Evaluation Advisor
Elsy Salnave	USAID/Haiti	Health Systems Strengthening Advisor
Sebastian Milardo	USAID Haiti	Health and Population Officer
Ceremy Fertil	USAID Haiti	Maternal & Child Health Advisor
Daniel Impoinvil	CDC	Research Entomologist
Dr. Gabriel Thimothé	*Ministère de la Santé Publique et de la Population (MSPP)*	*Directeur General*
Frantz Lemoine	*Programme National de Lutte Contre la Malaria (PNCM)*	*Coordinateur des Programmes Malaria/Filariose Lymphatique*
Paul Adrien	*Direction d'Épidémiologie, de Laboratoires, de Recherche (DELR)*	*Directeur*
Dr. Darline Carre Theodore	*La Direction d'Organisation des Services de Santé (DOSS)*	*Directrice*
Joseph Donald Francois	*L'Unité d'Appui à la Décentralisation Sanitaire (UADS)*	*Directeur & Coordonnateur National, Cholera*
Jules Morel	Haitian Mosquito Control Association	Director
Kurt Friedmann	Dynamic Aviation Group Inc.	Business Development Manager | Public Health and Safety

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