ENTOMOLOGICAL MONITORING, ENVIRONMENTAL COMPLIANCE, AND VECTOR CONTROL CAPACITY

FOR THE PREVENTION OF ZIKA AND OTHER ARBOVIRUSES

DOMINICAN REPUBLIC

ASSESSMENT REPORT

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

The Health Finance and Governance Project
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Entomological Monitoring, Environmental Compliance, and Vector Control Capacity

for the Prevention of Zika and Other Arboviruses

Dominican Republic

Assessment Report

CONTENTS

ACRONYMS

ANC	Antenatal care
BCC	Behavior change communication
Bti	*Bacillus thuringiensis var. israelensis*
CDC	U.S. Centers for Disease Control and Prevention
CENCET	*Centro Nacional de Control de Enfermedades Tropicales* (National Center for the Control of Tropical Diseases
DR	Dominican Republic
EVCP	Entomology and Vector Control Program
GIS	Geographic information system
HFG	Health Finance and Governance project
HR	Human resources
IEC	Information, education, and communication
IRM	Insecticide resistance management
IRS	Indoor residual spraying
IVM	Integrated vector management
LAC	Latin America and the Caribbean
MoH	Ministry of Health
PAHO	Pan American Health Organization
PPE	Personal protection equipment
RT-PCR	Reverse transcription polymerase chain reaction
ULV	Ultra-low volume
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 (LAC) 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 the Dominican Republic (DR), 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. The assessment was conducted from June 19-25, 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.

By May 21, 2016, 3,313 suspected cases of Zika were reported in the DR, 73 of which were positively confirmed. Of the overall total of suspected cases, 450 were pregnant women in the first 24 weeks of gestation; 31 were confirmed as infected with Zika. Guillain-Barré syndrome, a rare nervous system sickness that may be associated with Zika, was suspected in 139 individuals; three were confirmed as positive.

The DR has a National Vector Control Program situated within the MoH's National Center for Control of Tropical Diseases (CENCET), which is responsible for the public sector response to *Aedes aegypti* and other arboviral vectors. The program has sufficient guidance documents, such as protocols and manuals, to direct field operations carried out by provincial vector control units. Vector control in the country is multi-pronged, and includes larviciding and adulticiding, reduction of mosquito breeding sites, and educating communities to lead local control efforts. There is a demonstrated capacity in country to collect and analyze epidemiological data, a critical element in the Zika response. Collaborations with the U.S. Centers for Disease Control and Prevention and the Pan American Health Organization ensure the program and the MoH receive periodic, updated technical guidance.

Although various elements are in place, key challenges must be addressed to mount a sufficiently robust response to Zika and limit its impact in the country. These include:

1. Lack of a national working group for vector control efforts, though a forum for Zika does exist.
2. Resources for Zika are centralized and directed largely towards detection and treatment of cases, as opposed to vector control and entomological monitoring.
3. A lack of entomological surveillance impedes geographic targeting of control interventions; inhibits the evaluation of ongoing control methods; and prevents the selection and use of insecticides that most effectively control local vectors.
4. The plan for preparation and response to Zika and other arboviruses lacks reliable data, technical depth, and the specificity required to form the basis of a robust program for vector management. Moreover, there is only one public health entomologists in the MoH to lead the development of a new plan.

5. The availability of well-maintained insecticide application equipment at the regional warehouse in Santo Domingo is minimal. Measures to ensure the safety of warehouse employees, spray operators, and the environment do not meet international standards.
6. Though communities are engaged in source reduction efforts, support is needed to ensure the efficacy of their efforts. Comprehensive behavior change communication could strengthen these efforts, while also serving to mobilize additional members and groups.

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

1. Establish a vector control working group to encourage coordination and collaboration amongst stakeholders, maximize resources and capacity, and eliminate duplicative efforts.
2. Revise the Entomology and Vector Control Program (EVCP) to increase capacity for entomological surveillance and implement more selective and environmentally-sound vector control strategies such as integrated vector management and insecticide resistance management.
3. Increase systemic capacity for collection, analysis, and reporting of surveillance data by establishing an Internet-based system, considering integration of epidemiological and other data, and incorporating geographic information system capabilities.
4. Establish the position of a vector control quality assurance officer to oversee and support implementation at the field-level.
5. Develop a national capacity-building plan on vector control for field technicians and program managers.
6. Design and implement a comprehensive BCC campaign to facilitate improved source reduction efforts and reduce incidence of Zika transmission, particularly among women in their first trimester of pregnancy.
7. Improve the efficiency of warehousing facilities, while maximizing safety through proper handling of insecticides and application equipment.

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 region's response to Zika across four key technical areas: (1) service delivery, including maternal and child health, family planning, and child development; (2) social and behavior change communication; (3) innovation; and (4) 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 June and July of 2016 in five countries in the region: the Dominican Republic (DR), El Salvador, Guatemala, Haiti, and Honduras. The assessments 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

[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 the DR took place from June 19-25, 2016. The assessment team interacted with various stakeholders including representatives from the following institutions and organizations:

- National Ministry of Health (MoH)
    - Directorate of Provincial Health Authorities
    - Directorate of Epidemiology *(Dirección General de Epidemiología)*
- Ministry of Health entities working in Vector Control
    - The Entomology and Vector Control Program (EVCP) that sits within the National Center for the Control of Tropical Diseases (*Centro Nacional de Control de Enfermedades Tropicales* or CENCET)
- USAID/DR
- Red Cross
- World Vision

The team also visited a mosquito control unit in El Valle, a town about 100 kilometers north of Santo Domingo, and a regional warehouse facility in Santo Domingo used for storing equipment for *Aedes* control.

2. SITUATION ANALYSIS

2.1 Situation of Zika and Other Arboviral Diseases in the Dominican Republic

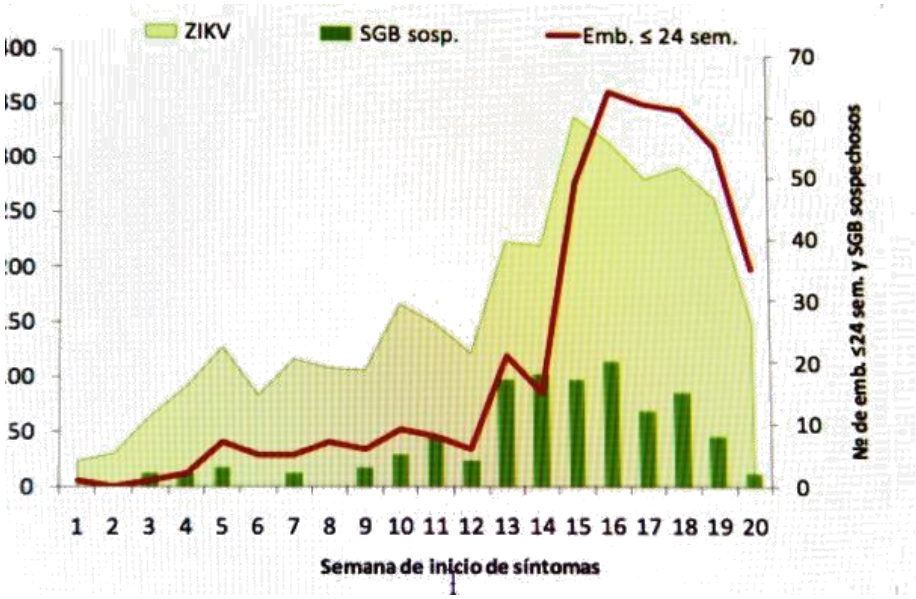
All 32 provinces in the DR are required to submit a weekly report on notifiable diseases—including Zika and related viruses such as dengue—to the countrywide disease surveillance system (*Sistema Nacional de Vigilancia Epidemiologica*). The system, managed by the Directorate of Epidemiology within the MoH, informs the development of a weekly bulletin that presents surveillance data, disaggregated by province, with short commentaries and analyses.

Through epidemiological week 20 of 2016 (May 15−21), the following Zika-related data were reported in the DR:

- 3,313 suspected cases of Zika, of which 73 (2%) were confirmed
- 139 suspected cases of Guillain-Barré syndrome, of which three (1%) were confirmed
- 450 suspected cases of Zika in pregnant women in their first 24 weeks of gestation, of which 31 (7%) were confirmed
- 0 confirmed cases of microcephaly

Figure 1 presents suspected Zika cases in epidemiological weeks 1-20 of 2016. Zika transmission (pale green shaded section) began increasing in January 2016 and peaked in mid to late April (weeks 15 and 16). The number of women infected in the first 24 weeks of pregnancy is displayed with the red line, and the green bars convey the incidence of Guillain-Barré syndrome. The chronology of the latter strongly suggests an association with Zika infection.

FIGURE 1: SUSPECTED CASES OF ZIKA IN WEEKS 1-20 OF 2016



Data on dengue, which shares the same vector as Zika[4] and is endemic in the DR, is presented in Figure 2 from the start of 2015 to almost midway through 2016. In the first part of 2016 (epidemiological weeks 1−20), there were 4,473 clinical dengue cases reported, of which 480 (12%) were classified as severe.

FIGURE 2: SUSPECTED CASES OF DENGUE IN THE DOMINICAN REPUBLIC FROM WEEK 1 OF 2015 TO WEEK 20 OF 2016

The data for dengue and Zika also convey an interesting point about the timing and seasonality of Zika transmission in the DR compared to the rest of the region. In the Caribbean, the incidence of dengue generally peaks in mid-rainy season, September to October. Figure 2 illustrates that transmission of dengue in the DR followed this trend, with the peak occurring in Weeks 41-42 of 2015. Given that dengue and Zika share the same vectors and environment, it would be reasonable to assume that Zika would follow a similar pattern.

As for Zika, transmission peaked in early 2016 in the DR, as well as in Haiti and Puerto Rico. Transmission was high enough for the epidemic to peak despite the season, but was suppressed by the arrival of the colder, dry season. If Zika follows the pattern seen with dengue, then a far higher incidence of disease can be expected when the "true" season begins. This will have significant implications in terms of vector control strategy and implementation.

[4] The *Aedes aegypti* mosquito carries dengue, Zika, yellow fever, and chikungunya viruses. Data on chikungunya, which also shares a vector with Zika, was not captured in the surveillance system and is therefore not discussed in this section. Other mosquito-borne arboviruses, such as Saint Louis encephalitis and West Nile encephalitis are rare zoonotic pathogens, outside the scope of this report.

2.2 Vectors of Arboviral Diseases and their Distribution in the Dominican Republic

Worldwide, *Aedes aegypti* is considered the principal vector for Zika. A second species, *Aedes albopictus*, is regarded as a secondary vector as it bites vertebrates in addition to humans.[5] Although no vector surveillance system exists in the country, both species are vectors of other human arboviral diseases such as dengue and chikungunya and therefore prevalent in the DR. While the two species are common in both urban and rural areas, *Aedes albopictus* tends to be more prevalent in areas with greater vegetation, and due to its non-host-specific feeding behavior, it more easily breeds away from human habitation. The two species also differ in biting patterns. The *Aedes albopictus*, is a more aggressive biter, with multiple bites per feeding which enhance transmission.

Both species originally relied on small, natural pods—tree-holes, plant axils, fruit husks, and rock-holes—to breed.[6] They have since adapted to the human peridomestic environment and are able to reproduce in almost any artificial container—water storage vessels, discarded tires, saucers under flowerpots, and so on.[7] The burgeoning, closely-packed cities of the Caribbean thus provide an environment conducive to quickly expanding epidemics.

Given the DR's mountainous terrain (with some peaks more than 3,000 meters [approximately 10,000 feet] high), altitude is a consideration with respect to Zika. In Europe, *Aedes albopictus* has been found in tiny, isolated villages in the Albanian Highlands, at altitudes up to 1,200 meters. *Aedes aegypti* is present up to 2,200 meters in Colombia. Thus, it is fair to assume that there is likely no altitudinal limit to either species in the DR.

2.3 Vector Control Interventions in the Dominican Republic

Vector control is limited and consists of community-oriented environmental sanitation coupled with sporadic suppression of vector populations directed by the MoH provincial health teams. For the latter, the application of thermal fogs based on entomological surveillance is conducted twice per year. Resistance in Santo Domingo to organophosphate (malathion) and pyrethroid (permethrin and deltamethrin) adulticides has been recorded since 1988.[8] Widespread application of the organophosphate temephos in water containers is also conducted, though resistance was documented in the same report for *Aedes aegypti* and *Aedes albopictus*.

[5] Many closely-related *Aedes* species, i.e., *Aedes Aedesbahamensis* and *Aedes Aedes mediovitatus* are able to be infected by the virus, but are unlikely to have any significant role in transmission

[6] 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

[7] Ibid

[8] Mekuria Y, Gwinn TA, Williams DC, Tidwell MA. Insecticide susceptibility of Aedes aegypti from Santo Domingo, Dominican Republic. J Am Mosq Control Assoc. 1991;7(1):69-72.

3. FINDINGS

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

3.1.1 National Level

Entomological monitoring and vector control activities are centralized in the DR within the MoH and fall under the purview of the EVCP of CENCET. [9] The MoH collaborates with other government entities such as the Dr. Defilló National Public Health Laboratory, and external organizations such as United States Centers for Disease Control and Prevention (CDC) and the Pan American Health Organization (PAHO). A comprehensive organogram, with description of the roles and responsibilities within the EVCP, was not available at the time of the assessment.

Effective implementation, including entomological surveillance and vector control, are hindered by a vertical organizational structure of the MoH, challenges in maintaining communication and continuous follow-up, and difficulty in prioritizing the use of human and financial resources. Funding for entomological monitoring and vector control activities consists of mostly internal, centrally-managed sources. The majority of resources are directed towards detection and treatment of cases. The limited remaining funds are used mainly for vector control, at the expense of entomological surveillance, which is conducted only sporadically. There is no specific funding for the arboviral diseases transmitted by *Aedes* species.

CENCET is responsible for the prevention and control of malaria, dengue, intestinal parasites, schistosomiasis, and the elimination of lymphatic filariasis. CENCET helps supervise the entomological and vector control activities of the provincial entomological monitoring and vector control units, including standardization of operations. The Director of CENCET noted that the National Program for Prevention and Control of Dengue, which focuses its efforts on the largest towns and cities within the country, integrates several vector control approaches. These include source reduction by program personnel; larviciding with Abate; adulticiding with hand-held thermal foggers and truck-mounted ultra-low volume (ULV) machines; and public education to encourage community-based control.

The Dr. Defilló National Public Health Laboratory has an insectary and staff trained to conduct vector-related analyses.

The *Sistema Nacional de Vigilancia Epidemiologica* is an important foundational element for epidemiological surveillance in the country. Yet, there is a need for a coordinated, national plan that integrates entomological surveillance and *Aedes* vector control activities to enhance its usefulness. Scarce resources and limited availability of trained personnel are challenges that must be considered prior to the implementation of new and/or novel mosquito control methods or the implementation of a more comprehensive routine entomological surveillance system.

[9] http://www.msp.gob.do/cencet-web/documentos/ENTOMOLOGIA/DESCRIPCION%20ENTOMOLOGA%20Y%20CONTROL%20DE%20VECTORES.pdf

3.1.2 Subnational Level

At MOH Provincial Directorates, there are entomological monitoring and vector control units that are tasked with controlling specific vectors and their predominant diseases. There is one unit for each province, with the exception of Santo Domingo, which has two. Each unit consists of a field worker and a supervisor who acts as the liaison between the unit and the central office for planning, management, and reporting purposes. In practice, however, the provincial units are largely autonomous and conduct their work based on information received from the local district clinics with little input from the central level.

Provincial units typically respond to reported cases by treating the surroundings of the homes. There is, however, often a significant time lapse between a reported case and treatment. In general, control efforts against *Aedes aegypti* tend to be infrequent and small-scale. Routine control methods include hand-held thermal fogging, high volume spraying using motorized backpack sprayers, truck-mounted ULV and direct application of larvicides (*Bacillus thuringiensis var. israelensis*, Bti or Abate™). However, these efforts are hindered by the capacity of the country's field personnel, discussed in more detail in the Human Resources (HR) section below.

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

3.2.1 National Level

The MoH and partners have not formally established a technical working group, to coordinate an intersectoral response to Zika and other vectors. There is evidence of periodic, informal collaboration by the MoH with partners, such as with CDC for technical advice. The CDC has also funded projects that target the strengthening of analysis capacity and epidemiological surveillance in the country. The assessment team was unable to secure a meeting with CDC representatives to discuss these and other efforts.

Non-governmental agencies are involved in mobilizing communities to limit the impact of vectors, such as through community-wide clean-up projects. Community groups form clean-up crews that educate the population on Zika, and collectively work to eliminate breeding sites. Yet there are challenges to achieving a more permanent change in behaviors, including those sanitation practices that could help reduce mosquito populations. At the time of the assessment, there were poster campaigns that explain how Zika is transmitted, although the posters were difficult to read and lack a memorable message.

3.2.2 Subnational Level

At the subnational level, public health teams are deployed to communities to inspect neighborhoods and eradicate mosquito breeding sites; conduct trash collection; and inform residents about vectors and how to control them. Apart from these occasional, small-scale efforts, broader approaches are uncommon, as is community-level surveillance to better target control initiatives against *Aedes* mosquitoes. Efforts to mobilize larger groups are typically reserved for the prevention of diseases deemed as having more severe consequences than Zika, such as cholera and typhoid. We did not observe widespread, targeted behavior change communication (BCC) or information, education, and communication (IEC) strategies in place for Zika, and foundlittle evidence of a systematic approach for planning, implementation, monitoring, or evaluating these campaigns or community mobilization efforts.

3.3 Human Resources

3.3.1 National Level

As mentioned in Section 3.1, entomological monitoring and vector control activities are centralized within the MoH in Santo Domingo. The EVCP coordinates all vector-borne disease control efforts, including entomological surveillance, provincial-level vector control, insecticide resistance surveillance, evaluation of biological efficacy of insecticides in use and alternatives, laboratory entomology, and environmental compliance. The assessment team was unable to verify in the field if these tasks are being carried out by the EVCP.

The country lacks a public health entomologist to develop, coordinate, and evaluate a national plan for arboviral vector control, entomological surveillance, and environmental compliance activities. Similarly, an adequately trained entomologist could oversee the appropriate tailoring of guidelines, protocols, and implementation plans to limit the *Aedes* population in the DR and thus the impact of Zika.

The Dr. Defilló National Public Health Laboratory has two dedicated laboratory technicians trained and able to perform the basic functions of an entomological laboratory within the insectary, including identification of adult and larval stages of *Aedes aegypti* and *Aedes albopictus.* It is unclear whether the Dr. Defilló National Public Health Laboratory has the capacity to train new staff in the event of staff turnover.

As of 2012, the DR's medical personnel consisted of 17,869 doctors and 15,748 nurses, more than 80% employed by the MoH.[10] Doctors are reportedly concentrated in urban areas. For example, in the National District there were 37.1 doctors per 10,000 inhabitants, while in the province of La Romana there were only 8.3 doctors per 10,000 inhabitants.[11]

3.3.2 Subnational Level

Each province has an MoH entomological monitoring and vector control unit situated within an MOH Provincial Directorate. The unit is staffed by one field worker and a field supervisor who serves as a liaison between the health and other Government sectors. Despite the presence and activity of a limited number of community groups, more human resources are needed to adequately control arboviral vectors. The assessment team was not able to obtain data on the full complement of staff involved in vector control.

3.4 Infrastructure

3.4.1 Presence of Reference Laboratory at the National Level

The Dr. Defilló National Public Health Laboratory, located in Santo Domingo, is equipped with sufficient personnel and materials to process routine vector-borne disease-related tests. Laboratory staff are trained to conduct larval and adult bioassays to detect chemical resistance using the CDC bottle bioassay technique, but may need additional training to conduct biochemical and molecular assessments of insecticide resistance. In addition to building staff capacity, the Dr. Defilló National Public Health Laboratory would need to be upgraded to run more advanced analyses, such as reverse transcription polymerase chain reaction (RT-PCR) and other vector-borne disease-oriented tests.

[10] http://www.one.gob.do/Estadisticas/126/recursos-para-la-salud
[11] Health in the Americas, 2012 Edition: Country Volume. Pan American Health Organization, 2012

3.4.2 Functional Insectary

A new insectary was recently built and is supported by two trained lab technicians. The assessment team did not observe evidence of mass rearing of mosquitoes or other insects, or susceptibility testing occurring at the facility. As noted above, more advanced functions of an entomological laboratory such as the ability to detect chemical resistance levels by molecular analysis (i.e. RT-PCR) are not currently available.

3.4.3 Warehouse Facility

The regional warehouse in Santo Domingo houses equipment and raw materials for vector control activities, such as insecticide spraying. Spray teams convene at this location to prepare their equipment before deployment to the communities.

In general, the safety and environmental conditions at the warehouse do not meet international standards. The organization of facility space urgently requires optimization to ensure the protection and safety of both equipment and personnel.

The chemical and equipment storage facility does not provide sufficient space for the proper storage of materials or equipment repair and maintenance. Insecticides are not stored in a centralized location, and are instead dispersed throughout the facility. Nearly 20 pallets of 50 bags each of 25 kg of Abate™ 1SG (temephos 1%) were found unsecured and in close proximity to other potentially hazardous materials. There was also evidence of Abate spillage, which likely occurred during dispensing, thus presenting a safety concern.

At the time of the assessment team's visit, large quantities of expired insecticide were kept, and in need of incineration. These occupied a sizable storage area and impeded its effective use. It was not clear if the expired product accumulated due to lack of the equipment to incinerate it or due to deficiencies in the program.

At the warehouse there was a large quantity of truck-mounted, London Fog™ ULV sprayers and Hudson X-Pert® sprayers in various stages of disrepair. The condition of these sprayers ranged from needing minor maintenance, like proper cleaning and lubrication, to extensive overhauling requiring replacement of major components. There is, however, no designated location within the facility to stage these repairs. The team did not review maintenance agreements. Poor usage of space was further evidenced through a recent purchase of Leco™ truck-mounted ULV sprayers. With no availability indoors, the sprayers were stored outdoors, unsecured and with little protection from the elements. Also related to on-site equipment, documentation pertaining to its maintenance and calibration was unavailable at the time of visit.

Further, the facility lacked adequate space for employees to efficiently and safely prepare for their work, such as separate changing areas for men and women and distinct areas for clean and contaminated equipment.

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

3.5.1 National Level

The Entomology and Vector Control Program plan has been prepared at the national level, but it lacks reliable data, technical depth, and the specificity required to form the basis of a robust vector management program. There is currently no entomological surveillance of Zika-transmitting *Aedes* mosquitoes, including shifts in vector density and/or behavior, which would inform better selection and targeting of vector control techniques. The lack of a public health entomologist on staff with the EVCP further impedes the development (and ultimately evaluation) of a national plan for arboviral vectors.

The capacity to map the transmission risk from various arboviral diseases is straightforward exercise and based wholly on the epidemiology of clinically diagnosed cases. Yet, data critical to conducting this type of analysis in the DR are restricted to the provincial level, therefore restricting the data's usefulness when planning and implementing nationwide operations.

The assessment team also observed a reliance on the organophosphate temephos, with limited use of Bti, thus increasing the selective pressure on the vector population and the likelihood of fostering insecticide resistance.

3.5.2 Subnational Level

There are no plans for entomological monitoring, vector control or environmental control at the provincial level. Provincial units conduct vector control activities in response to reported cases, not according to an established plan.

3.6 Implementation Capacity

3.6.1 National Level

The EVCP has adequate guidelines, protocols, and manuals to conduct operations targeting *Aedes* mosquitoes. Though the funding and level of logistical and technical support may imply otherwise, implementation and future expansion of the program are supported by national authorities and stakeholders. However, the technical and infrastructure capacity to effectively implement, as well as to monitor and evaluate, the current program is limited. Without reliable data related to entomological surveillance, vector control, and province-level epidemiological patterns, the national program is unable to effectively conduct basic analyses and mapping, target control efforts, and disseminate relevant data to the appropriate government departments and stakeholders. Moreover, EVCP managers have limited capacity to advocate for funding for program priorities. These obstacles will pose even greater challenges if the program, as expected, continues to grow.

3.6.2 Subnational Level

Subnational capacity needs strengthening to facilitate the implementation of a comprehensive, integrated control program. Minimal operational staff (i.e., one field worker and one supervisor per province), a lack of entomologists, and scarcity of funding preclude implementation of an *Aedes* control program and of establishment of entomological monitoring efforts, such as through community-wide surveys of aquatic stages.

Routine vector control is conducted by integrating several approaches: source reduction by program personnel; larviciding with direct application of Bti or Abate™; adulticiding with hand-held thermal foggers, high volume spraying using motorized backpack sprayers, and/or truck-mounted ultra-low volume ULV machines; and public education to encourage community-based control. Due to staff and funding deficiencies, however, implementation of these activities is infrequent; more precise data on the frequency of such activities was unavailable at the time of the assessment. The majority of *Aedes* control activities is reactive rather than routine and performed in response to disease outbreaks. In fact, resources are occasionally diverted from vaccination campaigns or similar activities to do so. Provincial units respond to reported cases by treating the surroundings of the homes from which cases were reported.

Outdoor space-sprays ("fogging") are widely used for *Aedes* control, particularly in response to outbreaks of disease. The impact of such treatments is limited, as they are only viable in the short time that the aerosol remains airborne and probably only when target insects are in flight. The dosages used, measured in ounces per acre (or ml/hectare), are too low to affect aquatic stages, so treatment does not interrupt emergence of adult mosquitoes. Indeed, there is little evidence of treatment efficacy in urban environments and, from an epidemiological standpoint, space-spraying is unlikely to alter transmission dynamics, except perhaps *after* the peak of epidemic transmission.

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

While the DR has demonstrated capacity to collect and analyze epidemiologic data, the collection and analysis of entomological data is limited across the country. Negligible amounts of data are recorded on paper or stored on local computers. Standard worksheets for vector monitoring and control are available but not regularly used, thus complicating aggregation of data and subsequent comparative analyses within and between provinces.

3.7.2 Capacity to Analyze and Interpret Data

The central database system used by district medical clinics to record clinical data suggests the existence of appropriate capacity to create a similar system for entomological surveillance, environmental compliance, and/or vector control data. The lack of data capture related to *Aedes* mosquitoes is the limiting factor.

Although collection and analysis of epidemiological data in the country is sophisticated and effective, the addition of geo-coding would facilitate improved mapping of suspected and confirmed disease cases. Whether for epidemiological or entomological data, geo-coding would take time and effort to put in place. Yet, its potential to eliminate human "transposition" errors in entomological monitoring could be of great utility for vector control. In the DR, the Red Cross has a state-of-the-art geographic information system (GIS) mapping project that supports risk mapping for flooding (see image on right). The project covers a large part of the country, with detail available down to the household level. The recommendation to collaborate was raised with representatives of the CENCET vector control programs and Red Cross.

3.7.3 Capacity to Produce High Quality Reports

As noted in section 2.1, the *Sistema Nacional de Vigilancia Epidemiologica*, produces a weekly bulletin that presents disease surveillance data by province with accompanying commentaries and analyses. If comprehensive and up-to-date entomological data were incorporated into the bulletin, it could be invaluable in informing routine and/or targeted vector control activities.

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

3.8.1 National Level

For epidemiological surveillance, there appears to be good coordination between health care providers relating to various notifiable diseases, including Zika. District clinics have access to a centralized database that is run and maintained at the central level. Information is analyzed, mapped and disseminated to all stakeholders via the weekly bulletin and Communicable Disease meetings. In contrast, the lack of entomological data limits stakeholder engagement on a similar level to plan and monitor activities related vector control.

3.8.2 Subnational Level

Stakeholder engagement at the provincial level is limited to non-governmental organizations, community and social groups, and residents assisting and participating in community clean-up campaigns. No evidence of technical or financial support from stakeholders relevant to use of entomological data was identified.

3.9 Insecticide Registration Status and Environmental Compliance

Insecticide registration in the DR falls under the purview of the agricultural sector. An updated list of insecticides registered for public health purposes was not available at the time of the assessment.

The regional warehouse in Santo Domingo for spray equipment, insecticides, and other supplies lacked adequate space for employees to safely prepare for their work, such as separate changing areas for men and women, and distinct areas for clean and contaminated equipment. Furthermore, large quantities of expired insecticides were found awaiting incineration.

4. Key Issues and Challenges

Below is a summary of the key issues and challenges identified by the assessment team:

1. There is no working group for vector control efforts, though a forum for Zika does exist. There is evidence of collaboration and coordination between the MoH and partners, though it is largely informal and not a routine component of the Zika response.
2. Resources for Zika are centralized and directed towards detection and treatment of cases, as opposed to vector control and entomological monitoring. Of the remaining funds, most are used for vector control, though the effectiveness of these efforts is unknown due to limited funding and thus implementation of entomological surveillance.
3. Entomological surveillance is neither routine nor systematic. As a result, there is insufficient entomological data with which to combine with epidemiological data and geographically target control interventions. The scarcity of such data also inhibits efficacy and resistance testing of insecticides; the evaluation of ongoing control methods; and the monitoring of the behavior and ecology of local vectors. Even with a more comprehensive program, however, the absence of a centralized Internet-based platform restricts the use, dissemination, and reporting of surveillance data.
4. The Entomology and Vector Control Program plan lacks reliable data, technical depth, and the specificity required to form the basis of a robust program for vector management. Moreover, there are no public health entomologists in the MoH to update the plan or lead the development of a new one.
5. The availability of well-maintained insecticide application equipment at the regional warehouse in Santo Domingo is minimal. Measures to ensure the safety of warehouse employees, spray operators, and the environment do not meet international standards.
6. Though communities are engaged in source reduction efforts, support is needed to ensure the efficacy of their efforts. Comprehensive behavior change communication could strengthen these efforts, while also serving to mobilize additional members and groups.

5. RECOMMENDATIONS

5.1 Recommendations to the Government of the DR

1. **Establish a vector control working group or similar forum at the national level to coordinate stakeholders around the Zika response**. Participants should include government authorities as well as non-governmental and community-based organizations.
2. **Dedicate more human and financial resources to slow the spread and impact of Zika**. Though the incidence of malaria appears to be increasing, this need does not warrant the shift of resources away from Zika. Specifically, the government should provide the EVCP with a dedicated budget for staff and training (see Government Recommendation 6), as well as the following:
    - Infrastructure improvements: see Recommendations for warehousing and insectary (see Recommendations 7 and 8)
    - Application equipment for ULV, with spare and replacement parts
    - Personal protection equipment (PPE) and emergency management equipment, including spill kits and fire suppression equipment
3. **Reformulate the EVCP.** The EVCP should be revisited to increase the capacity for entomological surveillance and implementation of more selective and environmentally-sound vector control strategies, such as integrated vector management (IVM) and insecticide resistance management (IRM). Specifically:
    - Consider boosting the capacity of EVCP at the national level in planning and implementation of entomological monitoring and vector control activities by hiring properly trained personnel preferably public health entomologists or training the existing staff.
    - Ensure that sub-national staff responsible for the gathering entomological monitoring data have the necessary skills and knowledge to collect good quality entomological data through training, mentorship, and provision of standardized data collection tools and protocols.
    - Moblize finacial resources (domestic and donor) to consistently collect entomological data on important entomological indicators to assesss the risk of transmission and inform timing for deploying vector control intervention.
    - Develop/update vector control strategy in colaboration with all incountry partenrs involved in response to Zika prevention.
    - Ensure that the EVCP scales up source reduction and environmental management activities to improve the effectiveness of vector population suppression efforts where feasible. Incorporation of IVM strategies could also enhance the success of interventions by reducing vector populations beyond what is achievable with insecticides.
    - Evaluate IVM interventions through entomological surveillance, monitor the effectiveness of insecticides in use, and assess the emergence and spread of insecticide resistance in the vector population.

- Develop a national IRM plan to minimize selection pressure on vectors and ensure that only insecticides to which vectors are susceptible are used. Initiate resistance mitigation approaches such as rotation of insecticides.

4. **Increase systemic capacity for collection, analysis, and reporting of surveillance data.** This would include:
   - Development of an Internet-based system for entomological database that allows use of various devices to upload data and facilitates realtime acess and analysis, use, and dissemination. Capture community-based efforts as well as more routine government-sponsored monitoring data.
   - Considering the creation of a system that combines data for entomological surveillance, vector control, and epidemiological data.
   - Engagement with the Red Cross to harness its GIS mapping system for epidemiological and operational surveillance data. Develop a pool of technicians skilled in GIS (see Government Recommendation 6) for the collection of epidemiological and operational surveillance data as part of the implementation of an IVM program.
5. **Develop a BCC and IEC campaign that targets pregnant women** in their first trimester to reduce incidence of Zika during a high-risk period (See Addendum 6.1 for detailed discussion).
6. **Develop a national capacity-building plan on vector control for field technicians and program managers**. The plan should include establishing a training program for entomological surveillance and vector control, and developing a pool of technicians skilled in GIS for the collection of epidemiological and operational surveillance data as part of the implementation of an IVM program.
7. **Improve the safety and effectiveness of central and subnational warehouse facilities**:
   - Introduce an insecticide management plan that ensures that insecticide storage facilities and the protocols for handling, transport, use and disposal of insecticides comply with local environmental and international regulations and conventions.
   - Modify the floor plan of the central warehouse to designate separate storage spaces for clean and contaminated equipment and materials, and separate clean and contaminated changing rooms for male and female workers.
   - Develop standard operating procedures and safety protocols for storage and handling of insecticides and application equipment. For example, spill kits and emergency protocols should be included in all vehicles transporting hazardous materials and placed in visible and accessible locations at storage facilities.
   - Conduct an inventory of all materials and equipment in the warehouse. Develop a maintenance and repair plan for sprayers and other equipment.
   - Provide warning labels in Spanish at all entrances alerting visitors to the presence of hazardous materials. Consider specific warehouse signage (more detailed recommendations, including diagrams and suggested signage, can be found in Annex C).

5.2 Recommendations to Donors

1. **Support establishment of an online training course focused on the surveillance and control of arboviral vectors**. The course would target entomologists, entomology technicians,

and vector control program staff. While an online training would be more sustainable and cost-effective alternative, an in-person training-of-trainers may also be feasible. Specific training topics could include mosquito surveillance methods, proper deployment of vector population suppression methods, and the use, maintenance and repair of spray and laboratory equipment (including PPE). A certification exam at the end of each topic would ensure that those who have taken the course meet the required standard.

The online training course could also be made available to all countries in the region, hosted by PAHO's virtual campus platform [https://www.campusvirtualsp.org/en] or the Caribbean Public Health Agency, CARPHA. The cost to create the online course would likely be around $200,000 and could provide permanent, ongoing training for all countries in the Americas, as well as stimulate interest in public health entomology.

2. **Support the establishment of a position for a Vector Control Quality Assurance Officer**. The EVCP in its current form suffers from limited financial and human resources. Until that changes, donors should consider funding a quality assurance officer who would work to accelerate improvements in the quality of all aspects of the EVCP, with particular focus on operational elements at the subnational level. This would include assessing and supporting vector control and surveillance activities via routine supervisory visits, addressing capacity issues through on-the-job training; and liaising with national-level managers to report on field-level progress of the program. Upon establishing the position, an absorption plan should be put in place for the officer to eventually be integrated into the EVCP.
3. **Share costs with the government of the DR through provision of funding or in-kind contributions.** This could include:
    - Essential recurring costs for the entomology laboratory, insectary, and/or warehouse facility
    - Biological and chemical control agents: insecticides, larvicides, insect growth regulator, mono-molecular oil, etc.
    - Novel approaches to *Aedes* control (see recommendation 4 below).
4. **Consider employment of novel approaches to *Aedes* control.**
    - A pilot perifocal treatment project at a small location that can be used as a template for a national plan and serve to train staff at all levels of the organization in the management and implementation of a vector control program (see Addendum 6.2 for detailed discussion).
    - Aerial treatments with larvicides, Bti (a bacterial insecticide) and Methoprene (a juvenile hormone analog that disrupts larval development), based on unpublished positive results from Florida (See Addendum 6.3 for additional details).

6. ADDENDUMS

6.1 Maximize Protection of Pregnant Women

In addition to implementing an IVM program to suppress the vector population, a comprehensive BCC and IEC campaign targeting women in their first trimester of pregnancy is proposed to help reduce incidence of Zika during this high-risk time period.

Under the proposed initiative, pregnant women in their first trimester would be instructed to apply DEET at least twice daily to all exposed skin, particularly in early afternoon and as early as possible in the morning (to target effect during the periods—afternoon-evening and early morning—when Aedes aegypti is most active).

The least expensive formulations of DEET are creams, but sprays are easier to apply. Consider a product with perfume and packaging attractive to women to improve uptake.

For women who are found to be infected with the virus, the campaign would also:

- Contribute to the surveillance and treatment of mother and fetus until childbirth; and
- Reduce the risk that Zika is transmitted between mothers, particularly when they visit the maternity clinic.

The campaign's strategic objectives could be to:

- Encourage women to visit a maternity clinic as soon as they suspect they are pregnant.
- Supply them with a mosquito repellent (DEET) and instructions on how to protect themselves for the six weeks or so until the end of their first trimester.
- Recommend all mothers receive a suite of standard tests (blood group, hemoglobin, HIV/AIDS, thalassemia etc.).
- Encourage them to obtain a sonogram using a simple, portable sonography machine and transmit it via Internet or on a hard disc to a specialist for interpretation and diagnosis.
- Encourage women to visit the clinic at every pregnancy (not only the first) even if birthing will be at home with a midwife.

During the assessment, discussions revealed that many women wait until the last days of their pregnancy before attending an antenatal care (ANC) clinic. If the selected strategy encouraged earlier ANC attendance, then this alone would be a desirable impact.

However, there are complex cultural issues that govern pregnancy and parturition in the Dominican Republic, and any campaign would need to be sensitive to these norms.

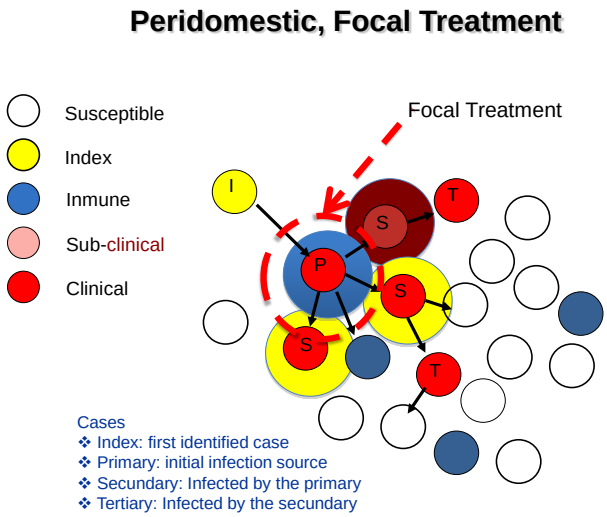
DEET has been marketed as a mosquito repellent since 1957. It is used by 50-100 million people per year, with very few reports of harmful side effects (mainly skin rashes) https://www.epa.gov/insect-repellents/deet#safety Laboratory studies have not revealed any effects on the foetus. There are no studies of DEET and women in the first trimester but the World Health Organization (WHO) http://www.who.int/features/qa/Zika/en/ and CDC http://www.cdc.gov/Zika/prevention/ recommend its use as protection against Zika.

Sexual transmission of Zika has been confirmed and is accepted by the scientific community, though little information is available. For this reason, women should also receive condoms and a leaflet directed at the partner explaining the importance of practicing safe sex during the critical trimester.

6.2 Pilot Trial

There have been two remarkable 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 1950s and 60s. By 1962, 18 countries had been declared free of the mosquito and of dengue.

In the eradication campaign, the principal approach was "perifocal" treatment (see image): field operators searched for infested containers and treated them[12] and surrounding surfaces to a radius of about 50 cm with DDT. These residual treatments kill mosquitoes on contact.



The success of the PAHO campaign may be attributable to a specific aspect of the behavior of the female mosquito, known as skip oviposition. *Aedes aegypti* lay up to 60-80 eggs per gonotrophic cycle, depositing a small number of eggs (or even a single egg) across many sites. This meant that, even if only a portion of infested sites was treated by field workers, it was highly likely that female *Aedes aegypti* would encounter a treated site.

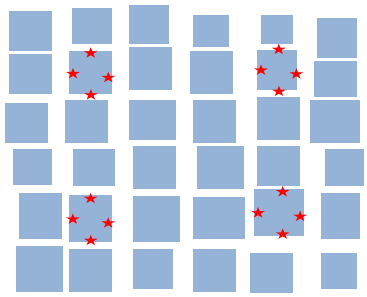
Though *Aedes aegypti* has regained territory in the region, its previous successes can be harnessed while recognizing new challenges. The assessment team proposes a small field trial to test the efficacy of a mix of interventions: new insecticide formulations, source reduction through community engagement, and larviciding. While a more comprehensive analysis is required to determine the optimal site for a pilot trial, the town of El Valle may be a suitable site. A non-adjacent community similar in relevant factors and where current interventions were expected to continue would serve as a comparison. The pilot trial would include the following steps:

1. Divide the site area in blocks of nine, using city blocks as a rough guide, and selecting a sample of central blocks (see Figure 3).
2. Deploy ovitraps in and around the selected blocks.
3. Monitor the ovitraps weekly for three to six weeks, recording the number of eggs collected at each to help identify high-risk areas.

[12] Applying insecticides with a compression sprayer

4. While source reduction methods and larviciding with Methoprene, Bti or other materials continue, conduct perifocal treatment ULV sprays using portable, motorized application equipment around primary cases to minimize the possibility of further transmission and maximize the protection of the population.

FIGURE 3: ILLUSTRATIVE OVITRAP DEPLOYMENT LOCATIONS



In addition, this method should be implemented in and around prenatal clinics and other medical facilities to protect pregnant women from *Aedes aegypti*. A search for mosquito sources in and around the clinic to a distance of at least 150 meters should be conducted. Containers that cannot be made mosquito-proof by physical means will be treated with a larvicide. For added protection, the internal walls of the waiting areas of these facilities could be treated with residual insecticides using a high volume, motorized backpack sprayer or a compression sprayer, both currently available.

A new formulation of a residual insecticide like Deltamethrin SC-PE (trade name Suspend-Polyzone®) could be used. This is a long-lasting, polymer-enhanced formulation that forms a stable, UV-opaque, water-proof deposit when sprayed on solid surfaces. The active ingredient, Deltamethrin, is widely used for insect control and approved for mosquito control by the WHO, CDC, European Commission etc. The manufacturer claims that the treatment can remain effective outdoors for at least three months (see: https://www.backedbybayer.com/pest-management/general-insect-control/suspend-polyzone). The WHO approves it for indoor residual spraying (IRS) for six months; in several studies, indoor persistence has exceeded 12 months http://apps.who.int/iris/bitstream/10665/90976/1/9789241506304_eng.pdf.

6.3 Aerial Spraying

Outdoor space-sprays ("fogging") are widely used for *Aedes* control, particular in response to outbreaks of disease. The impact of such treatments 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 treatment does not interrupt emergence of adults. Indeed, there is little evidence of treatment 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 strong support for air-spray to suppress the vector. Recently, three mosquito-control agencies in Florida have claimed almost complete eradication of *Aedes aegypti* through aerial treatments with larvicides, Bti (a bacterial insecticide) and Methoprene (a juvenile hormone analog that disrupts larval development). Its results are unpublished but merits attention and rigorous testing in the field. Methoprene likely holds the most promise as far smaller quantities are needed to have the same effect. A company with equipment suitable for citywide application of larvicides operates for Medfly control in Santo Domingo.

ANNEX A: LIST OF KEY CONTACTS

Name	Organization	Title/Role
Dr. Jim Wright	USAID	Mission Director
Elizabeth Conklin	USAID	Health Office Director
Eng. Ron F. Savage	USAID	Climate Change Office Director
Theodore Glenn	USAID	Chief, Democracy and Governance Office
Nelson Arboleda	CDC	Central American Regional Office Director
Dr. Hans Salas Maronsky	PAHO	Advisor on Communicable Diseases and Health Surveillance
Dr. Jose Manuel Puello	Ministry of Health	Director of Public Health Management
Dr. Luz Mercedes	MOH: National Center for the Control of Tropical Diseases (CENCET-MSP)	Director
Dr. Ana Figuereo	MOH: Directorate of Provincial Health Authorities	Director
Ing Solis	MOH	Epidemiologist
Dr. Ronald Skewes Ramm	MOH: National Program for Prevention and Control of Dengue, chikungunya and Zika	Coordinator
Dr. Alcibíades Hernández Olivero	MOH: Health Service Area I (Santo Domingo East Provincial Office)	Director
Dr. Juan de la Cruz	Provincial Health Office (La Vega)	Director
Dr. Freddy Abad Fabián	MOH: Health Service Region VIII (La Vega)	Regional Director
Dr. Altagracia Figuereo	Provincial Health Office (Santo Domingo)	Director
Claudia Valdez	MSH	Project officer
Sonia Brito	Capacityplus	Project officer
Dr Leonardo Arias, Director and Gustavo Lara	Red Cross	National Program for Community Health
Dr. José Sergio Abreu	World Vision	Director, Humanitarian and Emergency Issues
Dr Rossa Yvonne Nuñez	World Vision	Manager, Sustainability

ANNEX B: 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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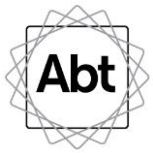

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| Johns Hopkins Bloomberg School of Public Health (JHSPH) | Results for Development Institute (R4D)
| RTI International | Training Resources Group, Inc. (TRG)

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

FOR THE PREVENTION AND CONTROL OF ZIKA AND OTHER ARBOVIRUSES

1. INTRODUCTION

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

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

2. ASSESSMENT CHECKLIST

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

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.)
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.		
• 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 (Wolbahcia), 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?		

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 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?		
• 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		

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.)
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.		
• 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		

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.)
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		
• Morphologically identify primary and secondary vectors of Zika		
• Conduct (annual) molecular analysis		

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.)
• 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		

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.)
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		
• 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.		

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.)
• 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		
• Identify and use proper adult *Aedes* mosquito sampling methods		

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 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)		

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.)
• 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)		
• 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.)		

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.)
• 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		

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.)
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		
• 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		

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○ 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		
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:		

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○ 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,		

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and environmental compliance		
• Entomological monitoring, vector control, and environmental teams have:		
○ Transportation services needed for the field work		
○ 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:		
o Proportion of breeding sites that are positive for aquatic stages of target mosquitoes (eggs, larvae, and pupae)		
o Species composition of the vectors		
o Vector distribution and seasonality		
o Vector resting behavior		
o Vector infectivity		

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.)
○ 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?		
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		

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.)
• 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		

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7.3 Capacity to Produce Good Quality Report		
• Produce good quality progress and final report that can be shared with stakeholders		
8. Stakeholders' Engagement and Use of Entomological Data to Inform Vector Control		
• The presence of functional cross-sector 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		

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.)
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?		
• 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: o Commercially licensed facilities that are accredited and licensed by the host governments to dispose toxic waste; o 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		

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turbulence in the gas stream to promote complete combustion; o 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 C: DETAILED WAREHOUSE RECOMMENDATIONS

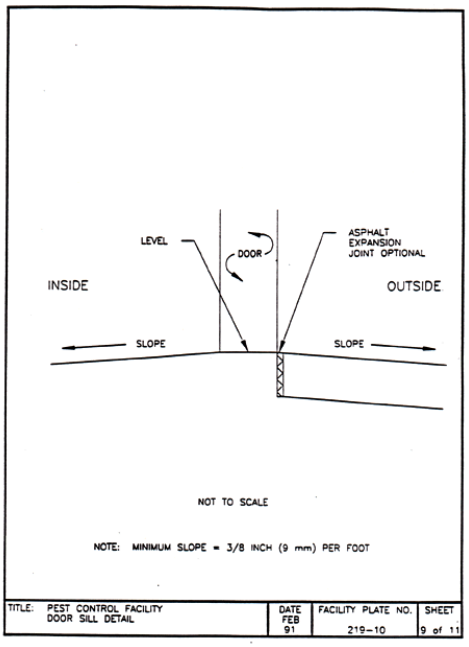
Overall Safety

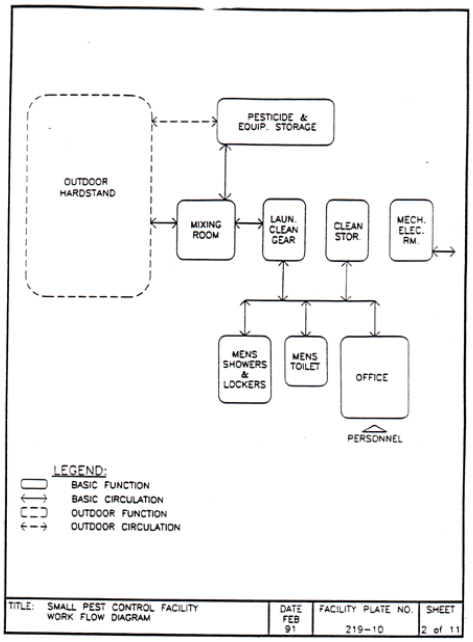
- Post warning labels in Spanish at all entrances and highly visible locations to alert visitors of the presence and hazardous qualities of the materials and contaminated equipment stored in the warehouse. Warning signs specific to storage facilities holding insecticides used in vector control are shown below (numbers 1, 3, 4, 6, 7, 8, 9, and 18).

HAZARDOUS MATERIALS WARNINGS

 1 No Smoking	 2 Telephone	 3 Hearing Protection	 4 Eye Protection	 5 Lockout Tagout	 6 Stand Clear
 7 Hand Protection	 8 Head Protection	 9 Hand Protection	 10 Hazardous Voltage	 11 Electrical Hazard	 12 First Aid
 13 No Cellphone	 14 Lock	 15 Fork truck	 16 No Fork truck	 17 Electrical Hazard	 18 Respirator

- Evaluate the warehouse flow plan to ensure that separate storage spaces for clean and contaminated equipment and materials are created, and that separate spaces are designated for female and male lockers/changing areas.
    - If needed, rearrange material stored in the regional warehouse to provide adequate separation between contaminated and clean items.
    - If possible, modify slope of the floor or place physical barriers to contain spilled materials and prevent liquid from escaping.





- Identify the locations of fire suppression equipment with large signs that can be easily seen from a distance and ensure equipment is appropriate for the materials stored and in good working order.
- Prepare and keep an emergency spill recovery kit in all spaces where dangerous materials and insecticides are stored. At minimum, a spill kit for dry chemicals should include a small shovel, dust pan and brush, two sets of rubber or neoprene gloves, two respirators designed for dusts and particulate matter—or appropriate for the materials sprayed—several large plastic bags where the collected spill can be kept and a bin of appropriate size (35 to 50 gallons) where all the material can be contained. A similar one for liquid insecticide will include all the items listed for dry materials plus two large bags of absorbent material like kitty litter granules. Spill kits should be kept in all vehicles transporting insecticide or other hazardous materials. Details on the local requirements should be available from local authorities.
- Coordinate with the country's environmental authorities so that all national and international rules and regulations regarding chemical storage, handling, application, and disposal are understood and enforced by all staff members.

Spray Operator Safety and Protection

- Issue at least one set of PPE to every spray team member who will be held responsible and accountable for it. The PPE should include two or three sets of cotton overalls with long sleeves and pants and collar, one wide-brimmed hard hat, a face shield, two sets of neoprene or rubber gloves, a pair of rubberized work boots or equivalent, and a respirator designed for dusts and particulate matter. A respirator rated for organic vapors should be worn by ULV spray operators during spray rounds. The selection and quantity of PPE will help maintain the health of the spray crews. If needed, conduct a respirator fit-testing and training to ensure all respirators fit properly and spray operators are afforded proper respiratory protection. The respirators should be labeled with the spray operator's number to ensure he/she uses his/her own for every use.
- Store all PPE in a separate, clean area away from the insecticide, flushing and cleaning agents, and chemical waste storage areas to ensure it remains clean before being worn.

Equipment Management, Maintenance and Repair

- Maintain inventory of the materials kept in the warehouse (updated at least on a weekly basis) and emergency contact numbers at every entrance. This information alerts emergency responders about the building's contents in case of fire, flood or other emergency, and could prove instrumental in reducing human and financial losses should an emergency occur. Label shelves and keep an inventory ledger to help locate items based on shelf number.
- Develop a warehouse keeper position or assign existing staff to fill this role on a rotational basis. Train these staff on the maintenance and repair of all sprayers and any other equipment used in the mosquito control campaign. Once the warehouse keepers have been trained, instruct them to train fellow team leaders and supervisors in minor repairs to the equipment to minimize down time in the field.
- Label each sprayer on a visible side with a sequential number and prepare a record of use, calibration, maintenance, and repair for each unit. A stenciled number can be painted on the sprayer so that each is identifiable. Once this is completed, assign a specific sprayer to each operator. Provide each spray operator with an agreement or code of conduct which outlines use, care, maintenance, and protocols should the sprayer become damaged or lost; discuss the code of conduct during training. This code of conduct would serve as a de-facto agreement with spray team members. This helps keep track of each sprayer and build a sense of ownership and responsibility for the spray operator.
- Make sure that spray operators clean their sprayers on a daily basis following the progressive rinse method. At the end of the season, the operator should thoroughly rinse the sprayer and return it in good working order to the warehouse manager or assistant.
- Conduct an assessment of the condition of the sprayers soon after the conclusion of a spray campaign to determine the type and quantity of spare and/or replacement parts needed for subsequent seasons. Process the resulting list and deliver it to the supplier/manufacturer as soon as possible. This will help the manufacturer of the parts produce the needed items and have them delivered prior to the start of the spray campaign.
- Transport all sprayers upright, secured to the vehicle and with no internal pressure. This will reduce accidental contact between the equipment (especially the pressure gauges) and vehicle during travel. This also prevents liquid from entering the pressure gauge.

- Designate a space in the warehouse close to an entrance as the workshop where maintenance and repair of the sprayers and other equipment will be conducted. This space would help maximize number of sprayers maintained and in active use and minimize faulty equipment and resulting down time
- Designate a part of the warehouse close to the workbench as a spare and replacement part section. Prepare shelves with storage containers and/or boxes where small parts can be stored. Create easy access by posting diagrams to help technicians locate specific parts.

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