Interim Assessment of the Response by the Hawaii State Department of Health to the Dengue Outbreak on the Island of Hawaii

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Executive summary

The response of the Hawaii State Department of Health to the ongoing outbreak on the Island of Hawaii has been timely, well considered, and appropriate. Coordination between State and County is excellent, and operations within Hawaii County are proceeding under an effective incident command structure at the Hawaii County Civil Defense Agency. All facets of a public health response to a dengue outbreak have been addressed adequately: community outreach, surveillance, diagnostic testing, medical care, and vector control. Nevertheless, the outbreak has revealed critical deficiencies in communications and medical entomologic capacities within the Department of Health that should be urgently addressed.

Mission

On request of the Office of Governor Ige, I assessed the response by the Hawaii State Department of Health to the ongoing dengue outbreak on the Island of Hawaii. I focused this assessment, conducted from December 1-4, 2015, on the following topics: 1) epidemiologic response, 2) entomologic assessment and control measures, 3) community outreach, 4) outreach to health care providers, 5) laboratory testing, 6) communications, and 7) coordination of response efforts.

Background

Dengue is a mosquito-borne viral disease spread from human to human via mosquitoes. No important non-human reservoir exists. Approximately 100 million dengue illnesses occur each year in endemic countries throughout the tropical world. Dengue virus is spread primarily by *Aedes aegypti* (yellow fever mosquito), an aggressive urban, human biting mosquito, which typically feeds indoors. In the Hawaiian Islands, *Aedes aegypti* is thought to be endemic only in certain areas on the Island of Hawaii, including the Kona Coast. In contrast, *Aedes albopictus* (Asian tiger mosquito) is widely prevalent throughout the Hawaiian Islands. Compared with *Aedes aegypti*, *Aedes albopictus* thrives in less urban habitats and transmits dengue less efficiently because it feeds on many other animals besides humans. Both species are daytime biters, breed in the ubiquitous small pools of water (man-made such as discarded tires and natural such as bromeliads) found in tropical environments, and adults may be in locations largely inaccessible to outdoor

spraying. As a result, mosquito control efforts have universally failed to stop or significantly slow contemporary dengue outbreaks.

Dengue has not become endemic to the Hawaiian Islands despite frequent introductions from infected travelers. However, introductions have occasionally resulted in outbreaks; the last major outbreak involved 122 laboratory-confirmed cases with disease onsets over a 9-month period in 2001 and 2002. Local transmission occurred on Maui, Oahu, and Kauai as a result of three separate introductions from infected travelers from Tahiti. *Aedes albopictus* was the mosquito vector. A study involving 4000 Hawaiian visitors during the outbreak period indicated minimal risk to visitors.

Infection from one of the four dengue viruses produces permanent immunity only to that virus, thus enabling up to four dengue infections over one's lifetime. While subsequent infections are associated with increased disease severity; disease severity is most influenced by the pathogenicity of circulating strains. Following infection, virus is present in the bloodstream for approximately a week, during which time feeding mosquitoes may become infected. Approximately a quarter of infections result in clinical illness, which may be manifested by fever, bone and joint pain, fatigue, rash, and gastrointestinal symptoms. Approximately 5% of ill patients develop severe dengue manifested by bleeding and shock. Proper recognition of impending severe dengue and clinical management greatly reduces morbidity and mortality.

Assessment activities

My discussions at the Hawaii State Department of Health in Oahu on December 1 focused on a review of extant epidemiologic data, surveillance activities and procedures, laboratory testing and procedures, and communication and outreach efforts. I also participated in regularly scheduled briefings with State Department of Health personnel on the other islands and with the Hawaii County Civil Defense Agency. On December 2, I reviewed procedures and ongoing activities at the Hawaii County Civil Defense Agency in Hilo, which is the outbreak incident command center on Hawaii Island. I also visited three case properties in the Hilo area. The following day, I visited two areas in south Kona where many cases had been reported and reviewed ongoing mosquito surveillance efforts. On December 4, I further discussed surveillance efforts, reviewed epidemiologic data, and reviewed communication and outreach efforts at the Hawaii State Department of Health in Oahu.

Principal findings, conclusions and recommendations

Epidemiology and surveillance

Principal findings

Hawaiian health care providers are required to immediately report suspect dengue cases, and laboratories are required to report requests for dengue testing. The

Hawaii State Department of Health was first notified on October 21, 2015 of a positive dengue test result in a person without previous recent travel off the Island of Hawaii and immediately began an investigation. The Hawaii State Department of Health then consulted with the Dengue Branch, Centers for Disease Control and Prevention.

The State's laboratory reporting system usually ensures timely reporting of new suspect cases. Once a report is received, Department of Health investigators obtain detailed clinical and epidemiological information by phone from suspect cases using a case report form modified from that developed by the Centers for Disease Control and Prevention and currently employed by the Puerto Rico Department of Health. Investigators make at least three attempts to contact suspect cases. Consent for the interview is high among confirmed cases, but is less among suspect cases not confirmed to have dengue. Nevertheless, the comparison of information from these two groups will be valuable. It is also noteworthy that the ratio of reported persons with dengue ruled out to those ruled in has increased, indicating the threshold for physician-ordered testing of persons with dengue-compatible illness has decreased. In addition to laboratory-based and physician reporting, infection control personnel at the three hospitals on the Island of Hawaii report patients admitted with dengue-like illness.

Many of the early cases had exposures to Hoʻokena State Park, a popular camping destination for Island residents. Three groups of Park visitors (one tourist and two Hawaii Island resident groups) had multiple members who acquired dengue infection. Infected resident group members subsequently initiated transmission chains after their return to their home communities. Based on these findings, the County Mayor immediately closed the Park. In addition, the Hawaii Ironman Competition organizers notified participants of the outbreak, and suspect cases have been followed up by the Hawaii State Department of Health.

Maps indicating the approximate locations of residence of dengue cases are posted on the State Department of Health website.

Surveillance data indicate most transmission is occurring in South Kona, with neighborhood and household clustering. Discussion with local residents suggests that many persons with dengue-like illness in the area have not sought medical care and thus are not identified by surveillance. This underreporting is typical of dengue outbreaks elsewhere.

While the State Department of Health has been able to maintain basic surveillance and case follow-up, existing epidemiologic resources are taxed and could be overwhelmed if another health crisis arises.

<u>Conclusions</u>

- Surveillance is timely and sufficiently sensitive to monitor temporal trends and geographic patterns of spread. While the surveillance system likely identifies all

diagnosed persons, the true number of dengue illnesses may be much higher because many persons with mild illness may not seek medical care. This is not a failure of surveillance as the goal is not to identify every patient.

- The epidemiological response has been timely and well considered. However, current resources are taxed, and there is limited surge capacity if another significant health event arises in the State. While basic surveillance data have been analyzed, staffing limitations and the need for epidemiology staff to respond to communication needs have left little time for in-depth analysis of existing data and little surge capacity to conduct additional in-depth investigations if the need arises.

Recommendations

- Current surveillance should be maintained as is.
- Short-term epidemiologic needs should be critically assessed and additional resources garnered as required. I am concerned about staff fatigue and a potential crisis if another health event develops. Epidemiologic assistance from CDC is available as needed.
- An assessment of epidemiologic capacities should be made to determine long-term needs. While highly skilled expertise resides in the Department of Health, limited surge capacity for such technical proficiency exists for public health emergencies such as the dengue outbreak.

Entomologic assessment and control

Principal findings

Mosquito control should follow integrated pest management practices: environmental management (reduce mosquito breeding sites and minimize human-mosquito contact), larvicides when mosquito breeding sites cannot be eliminated (such as water cisterns and bromeliads), and adulticides to reduce the density of adult mosquitoes. While one or more of these approaches have been employed during many dengue outbreaks elsewhere, little evidence exists of their efficacy in reducing dengue incidence.

Vector control may be particularly problematic in outbreak areas on the Island of Hawaii. Abundant man-made and natural (e.g., bromeliads) mosquito breeding sites, particularly considering the dense vegetation around households (see photos below), make it less likely that sufficient numbers can be eliminated or treated to significantly impact mosquito breeding. Considering the flight range of vector mosquitoes, a neighborhood wide approach to adulticiding will likely best reduce adult mosquito populations. However, the large distances between houses, dense vegetation, homeowner reluctance (many organic farms in the area and general opposition to chemicals), homeowner not at home, unoccupied homes, and large staffing and equipment requirements likely present unsurmountable obstacles to this approach. It should also be noted that the outbreak is occurring over a very large area and only a small percentage of properties could be treated using this

approach (although “hot spot” areas with a higher density of cases could be targeted).

Given these limitations, the current mosquito control strategy focuses on treatment of case houses with the goal of reducing mosquito infection and subsequent human transmission from known cases. An adulticide, Aqua Reslin (contains the pyrethroid permethrin and piperonyl butoxide), is sprayed within a 25-yard radius around case houses. Because the flight range of *Aedes aegypti* and *Aedes albopicutus* exceeds 25

yards, the efficacy of adult mosquito control limited to this range is unknown and requires evaluation. Some other properties such as schools have been sprayed, but there lacks a systematic approach to non-case properties and the rationale for treating them is unclear.

In addition, a "mosquito survey" is conducted once in a 200-yard radius around case houses. Mosquito breeding sites are eliminated (such as dumping containers) or treated with a mixture of soapy water. The control perimeters may extend beyond the property line, so in practice control efforts may cover a smaller area than outlined by protocol. The extent of variation and thoroughness of the mosquito survey among vector control staff is not clear. Reports from the field suggest that only about 25% of households within the 200-yard radius have been surveyed due to homeowners not being present or refusing to allow survey crews on their property. It is thought that a participation rate of 90% may be necessary for this approach to lower mosquito densities sufficiently to impact dengue transmission.

Water cisterns as the only source of household water are very common on Hawaii Island, present in up to 80% of households in some locations. The contribution of these to mosquito breeding is unknown, and they are currently not treated. In addition, there is little scientific evidence to support the use of soapy water as a larvicide in the field, and there are no established standards for the effective combination of soap and water in mosquito control, as the combination varies greatly with application situations and types of soap used.

Vector control staff have been able to keep up with case house spraying but are getting fatigued, particularly those in the South Kona area where the highest concentration of cases have been reported. It is doubtful that the current effort is sustainable for long periods of time or if case numbers increase.

Entomologic surveillance and management for the entire state is conducted by two State Department of Public Health entomologists stationed in Honolulu. On Hawaii Island, vector surveillance is limited to two water ports and two airports, mainly to monitor for newly arrived invasive mosquitoes. Insufficient capacity exists to collect pertinent entomologic information such as the mosquito species causing the outbreak, assessments of aquatic habitats producing mosquitoes, and entomologic evaluation of implemented control measures.

A CDC entomologist and biologist now on site have augmented state capacities. Evaluation efforts are complicated logistically by the outbreak's occurrence over large areas with different ecologies.

Conclusions

Entomologic assessment has been hampered by lack of technical and general staffing capacity at the Department of Health. Detail of a CDC entomologist and biologist has greatly enhanced assessment activities in Kona. Longer term,

introductions of other mosquito-borne diseases such as Zika and chikungunya are likely and will require entomologic expertise at the State Department of Health that currently does not exist.

No known mosquito control measure will stop dengue outbreaks, and it is unclear whether any of the currently employed measures will reduce significantly the number of new cases. Spraying to kill adult mosquitoes has potential benefit if it results in an immediate, significant, and sustained (a week or more) reduction of vector mosquitoes sufficient to reduce biting of dengue virus infected persons. However, quantitative data on efficacy in reducing mosquito populations around case households is lacking. Current efforts to reduce mosquito breeding sites may be insufficient to reduce mosquito populations enough to impact transmission because soapy water as a larvicides may be ineffective and it has proven difficult to achieve the 200-yard radius of control. Current vector control activities on the Kona Coast are likely unsustainable if incidence increases or the outbreak persists.

<u>Recommendations</u>

- Additional short-term resources to help with entomologic surveillance and trapping would be useful. The Department of Defense has skilled personnel in the State. The University of Hawaii or other State government organizations may have trained entomologists, but entomology personnel with specific experience with mosquito-borne diseases in outbreak settings and public health response would be most useful.
- Longer term, there exists an urgent need to restore entomologic capacity lost in the State Department of Health in recent years.
- Given the unknown efficacy of any vector control approach for dengue in the Hawaiian context and disappointing efficacy of vector control found in outbreaks elsewhere, realistic expectations should be promulgated to the public and the efficacy of the approach evaluated entomologically. Two options for control can be considered:
    - Continue the current strategy with modifications that may improve efficacy.
    - Switch to a neighborhood wide approach. While this approach may in theory have the greatest possibility of success in a very limited area, it is very unlikely to be feasible and achieve sufficient coverage to be effective for the reasons outlined above.
- Detailed recommendations for vector control are outlined in Appendix 2.
- Entomologic research needs to help respond to this outbreak and to prepare for the potential introduction of dengue or other mosquito-borne diseases on all of the Hawaiian Islands are outlined in Appendix 2.

Community outreach

Principal findings
Hawaii County has largely taken the lead on local community outreach activities, which critically augment personal protection behaviors, increase health care seeking among persons with dengue-like illness, and encourage elimination of mosquito breeding sites around households. Hawaii Island has many hard-to-reach populations, including migrant farm workers, homeless, and persons who deliberately isolated. County and State officials are working through a wide range of organizations that deal with these disparate groups (Appendix A). Capacities are being developed to conduct mobile blood draws for persons unable or refusing to go to a medical facility.

An average of 12,000 tourists stay overnight on Hawaii Island. Most tourists are currently at low risk for dengue (limited duration of stay, spend most of their time in areas without significant mosquito populations such as the beach, reside in air conditioned rooms). County and State Officials have reached out to tourist organizations (Appendix A). While I did not systematically evaluate the outreach to tourists, I did not receive any information about dengue at my hotels in Hilo and Honolulu and saw no dengue-related information in the Honolulu, Hilo, and Kona airports. Materials have been posted subsequently at the Hilo and Kona airports.

Conclusions
While an extensive community outreach effort is underway, the endpoints of the outreach effort have not been well defined, and there has been no effort to establish performance levels and measures of success.

Recommendations
- Given the limited efficacy of vector control, continue messaging regarding personal protection, property management (eliminating or treating breeding sites), and use of barrier methods such as screens.
- Practical goals and performance measures should be established (percent of hotels with information available to guests, all airports with signage, etc.).
- Knowledge, attitudes, and behavior (KAP) surveys should be considered to evaluate public knowledge about dengue and changes in behavior as a result of the Fight the Bite campaign and other prevention messaging.

Outreach to health care providers

Principal findings
Prompt recognition and effective treatment of severe dengue can greatly reduce morbidity and mortality. The State Health Department has issued several health alerts and has given several informational briefings for health care providers. A CDC expert participated in one of these. It is noteworthy that a representative of the Health Care Coalition is on site at the County Incident Command Center in Hilo. While few patients have been hospitalized in Hawaii, an effort is underway by the State Health Department to examine the reason for hospitalization and medical care

delivered. Examination of case report forms of patients where dengue has been ruled in or out will also help to evaluate provider testing practices.

Conclusions
Dengue related illness so far has been mild with few hospitalizations and no deaths. Current outreach efforts seem sufficient.

Recommendations
Continue current activities.

Laboratory testing

Principal findings
All commercial laboratories in Hawaii currently funnel samples submitted for dengue testing to the State Laboratories Division. The State Laboratories Division testing algorithm (PCR for patients whose blood was drawn early in their illness [<8 days post symptom onset], IgM ELISA for patients whose blood was drawn >7 days post symptom onset [6 or 7 days if PCR negative in a patients with findings consistent with dengue fever]) is appropriate. The State Laboratories Division employs the FDA approved PCR test developed by CDC. Early in the outbreak, CDC validated State Laboratories Division dengue testing results and tested samples for other mosquito-borne pathogens (Zika and chikungunya) circulating in the Pacific. Laboratory result reporting turn-around early on was a problem largely due to delays in submitting samples to the State Laboratories Division and receiving and reporting results to clinicians by commercial laboratories, but these issues have largely been resolved. The State Laboratories Division tests specimens within 24 to 48 hours of receiving them and transmits those results to the clinical care coordinators at the submitting commercial laboratories.

Conclusions
Current laboratory testing protocols are state of the art, and turn-around of results is generally very rapid. The procedures now instituted for expedited shipping and funneling samples to the State Laboratories Division as rapid reporting of test results will be useful when other health emergencies arise.

Recommendations
Continue current activities. There is no need to establish dengue laboratory testing on Hawaii Island or encourage the use of dengue rapid tests as the State Laboratories Division is very proficient at performing the best tests available and quickly reports results.

Communications

Principal findings
The State of Hawaii's diverse population spread over several islands creates communications challenges not found elsewhere. In addition, effective

communications strategies now must include social media and other non-traditional outlets. The dengue outbreak soon overwhelmed the one full-time communications professional at the State Health Department and a public relations firm was hired. The public relations firm initiated the Fight the Bite campaign as well as other outreach activities, but funding for the public relations firm will be exhausted shortly. No consistent and proactive media strategy is evident. As a result, media reports have expressed undue controversy and uncertainty regarding statewide response efforts and opportunities for positive health messaging have undoubtedly been lost. While the State Health Department's dengue web site contains up to date and useful information, it is not organized in an attractive and user-friendly manner that attempts to convey key information to constituent groups such as health care professionals.

Conclusions
Communications capacity at the State Department of Health is woefully inadequate.

Recommendations
- Short-term gaps will be partially filled by detail of CDC communications experts.
- Longer-term, hiring additional communications personnel facile with social media and website management are needed to fill critical gaps. The CDC communications consultant can provide additional recommendations.

Coordination of response efforts

Principal findings
County health offices within the State Health Department organize public health on each of the Hawaiian Islands. This in part has resulted in a nearly seamless effort at county and state levels. Outbreak response on the Island of Hawaii is organized under a unified command under the leadership of the Administrator of the Hawaii County Civil Defense Agency. Participating agencies include the State Department of Health and county offices of Civil Defense, Fire, Parks & Recreation, and Public Works. The Offices of the Mayor and Governor also contribute to the unified command. Importantly, case investigations, mosquito control efforts, and many outreach efforts are carried out under this unified command. The coordination of efforts is one of the best I have witnessed anywhere.

Conclusions
The outbreak response is extremely well organized and serves as a model for others.

Recommendations
None.