Vector-borne Disease Control Plan for West Nile Virus in California, USA

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Vector Borne Disease Control Plan

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Introduction

Vector-borne diseases are illnesses caused by viruses, bacteria, or parasites and are spread by an arthropod vector (WHO, 2020). These diseases have the potential for significant illness or death in the population. One major vector-borne disease of concern within the United States is West Nile Virus, or WNV.

West Nile Virus is part of the Flaviviridae family, which includes other arboviruses such as Japanese encephalitis virus and St. Louis encephalitis virus (Habarugira et al., 2020). It causes high mortality in enzootic cycles with birds, horses, and reptiles; and can cause severe neuroinvasive illnesses such as encephalitis and meningitis within humans. The first case of West Nile Virus was discovered in the West Nile province of Uganda in 1937. It is now widely distributed around the world, and is endemic to Africa, Europe, Asia, Australia, and the Middle East (Habarugira et al., 2020).

West Nile Virus's main mode of transmission is through mosquito bites from the Culex mosquito species (Habarugira et al., 2020). WNV transmission includes many participants including reservoir hosts such as birds and crocodiles, a mosquito vector, and dead-end hosts such as horses and humans. Mosquitos first become infected with the virus when they collect a blood meal from an infected reservoir host. The virus travels to the mosquito's midgut, where it replicates and spreads back up to the salivary glands. The infected mosquito can then transmit the virus to hosts through their next blood meal. Other known modes of transmission between humans include intrauterine, breastfeeding, blood transfusions, and organ transplants (Habarugira et al., 2020).

West Nile Virus impacts the economy through healthcare costs for humans and veterinary care for horses and chickens (Keyel et al., 2021). Although this virus impacts human health, animals, and the economy; not much has been done to control future outbreaks, which has led the virus to become endemic to North America (Hadfield et al., 2019). Since its first emergence in the United States in 1999, there have been 51,801 human cases with fatality rates of 7% overall and 10% for severe neuroinvasive cases (Hadfield et al., 2019 & CDC, 2003). The highest number of West Nile Virus human cases occurred in California compared to all other fifty states (CDC, 2021).

West Nile Virus outbreaks occur in two major areas within California: Southern California and the Central Valley, which can be seen by observing a trend of high positive cases in Butte, Fresno, Kern, Los Angeles, Orange, Riverside, Sacramento, San Bernardino, Stanislaus, and Tulare counties (Danforth et al., 2021). 81% of the total cases were within these 10 counties, showing that WNV is not evenly distributed across the state (Danforth et al., 2021). Common characteristics of the populations within these counties included, higher mean population, higher population density, younger median age, and small proportions of people over 60 years old. Common characteristics of the location include low elevation, more development, and near local vector control agencies (Danforth et al., 2021).

The California Department of Public Health has responded to the threat of West Nile Virus through surveillance, education, and mosquito control (The California Mosquito-borne Virus Surveillance and Response Program, 2022). Although the public health department keeps up with surveillance with the help of Mosquito and Vector Control Association of California and UC Davis Arbovirus Research and Training, they have ineffective education and outreach efforts to inform the public about WNV. They also fail to address the different climates and conditions that vary between counties.

Disease Detection and Surveillance Plan

In California, West Nile Virus affects mosquitos, birds, horses, and humans. Epizootic infections from birds commonly spillover to humans through the mosquito vector, so it is important to run surveillance programs on birds to detect early disease risk for potential WNV spillovers to humans. The most common reservoir populations are birds from the family Cervidae which include American crows, jays, ravens, and magpies (Reisen et al., 2013). Recent studies have shown immunity to WNV within crow populations; therefore, surveillance of bird deaths in an area is not an accurate method of detecting WNV without other methods (Reisen et al., 2013). In addition, reporting of dead birds requires participation of civilians, which can vary from county to county (Komar, 2006). A more reliable way of surveillance of avian reservoirs is through captive sentinels. To detect WNV in California avian populations, chickens should be placed in known enzootic transmission areas and be blood tested weekly to monitor WNV (Komar, 2006).

Mosquito populations surveillance can be done through trapping techniques. The most effective trapping techniques for female Culex mosquitos are CO2-baited traps and walk-in red-box traps for male culex mosquitos (Reisen & Pfuntner, 1987). Trapping of larval mosquitoes requires taking dip samples from breeding areas (CDC, 2003). After trapping, diagnostic testing for WNV can be performed.

Diagnosis of WNV infections in humans include clinical examination of symptoms and diagnostic blood tests (Habarugira et al., 2020). Blood tests can test for viral load or antibodies. The health department should create testing stations where the public can be rapid tested using the RapidWN immunochromatographic strip that is low cost and user friendly (Habarugira et al., 2020).

Treating Infected Populations Plan

The incubation period of the symptomatic cases is 2-14 days (Campbell et al., 2002). The virus presents clinically in several forms such as an uncomplicated fever and more serious complications like encephalitis, although people infected with WNV are often asymptomatic. West Nile fever symptoms include sudden onset of fever, headache, fatigue, gastrointestinal problems, and rash. These symptoms typically last a week and resolve on their own. West Nile encephalitis symptoms include mental status change, vomiting, muscle weakness, and flaccid paralysis (Campbell et al., 2002).

Currently there is no cure for the West Nile infections and there are no approved vaccines (Campbell et al., 2002). Symptomatic West Nile forms are either too mild for treatment or too serious. In both cases, the only treatment is to treat the side effects. Mild cases should stay home and rest. Those suffering from the damaging complications from encephalitis can be given medications such as interferons and ribavirin that decrease viral activity (Alli et al., 2021). The main treatment with those with encephalitis include supportive care and pain management, which can be carried out through mobile clinics during outbreaks (Alli et al., 2021).

Therefore, the main way to care for people in the target population would be a vaccination program. Although there is no vaccine currently approved and available for use, there is a promising DNA vaccine for West Nile virus that is being developed (Chang et al.,

2008). Once it is approved, vaccine pop up clinics can help quickly distribute the WNV vaccine to high-risk populations.

Vector Control Plan

The Culex mosquito has two phases that can be targeted for vector control: the larval stage and the adult stage. During the larval stage, it is important to decrease instances of standing water because they tend to be breeding grounds for mosquitoes (CDC, 2003). The California Department of Health will need to have a task force that adds more drainage systems, thins vegetation where small pockets of standing water can form, and encourage farmers to use irrigation practices that limit extended periods of time for standing water (CDC, 2003). Mosquito fish will be released into small ponds and canals to eat the larvae. Implement these during the spring and summer months when breeding is most likely to happen.

To target the adult stage, insecticides can be used with traps (Habarugira et al., 2020). It is important to consider the efficacy against Culex mosquitoes, resistance status, availability of the pesticide, environmental conditions, cost, and toxicity to non-target species when choosing a pesticide. Another more environmentally conscious option is genetically engineered mosquitos. Genetically engineered mosquitoes offer two possibilities: the use of a refractory mosquito that replaces the vector populations or releasing a mosquito with a lethal gene (Wilke & Marrelli, 2015). This can be implemented with the help of the UC System's extensive mosquito research labs.

Measurement of effectiveness of control measures can be combined with vector surveillance. Effectiveness should look like lower mosquito populations, less infection samples from mosquitoes, and large numbers of genetically modified mosquitoes.

Public Health Education and Outreach Plan

Public health education to prevent transmission and future epidemics is crucial until we find a vaccine for WNV. The public should be informed about ways they can protect themselves from mosquito bites such as wearing long sleeves, using mosquito repellant while outdoors, and limiting time outdoors. The public can also participate in reducing standing water by disposing of old tires, cans, and buckets that can be breeding grounds for mosquitoes; and covering or draining their pools when not in use (Habarugira et al., 2020). The public should also be updated on infection rates in their area.

Currently, the California Department of Public Health has a website containing basic information about the disease, prevention, and pets; resources and yearly reports on WNV, and a section on how to report dead birds. Although many resources are presented, it is difficult to find specific information. The California Department of Public health needs to focus on specific target populations and implementing different ways to educate the target populations.

Education outreach efforts should be targeting high-risk WNV areas. Within those areas, the regions at most risk tend have high mean populations, high population density, and younger median age; and are in lower elevations with more development (Danforth et al., 2021). Since these areas tend to have higher populations, community-based events such as county fairs, presentations at local organizations, and senior forums will be the most successful types of outreach activities (Tembreull & Schaffer, 2005). It is also important to make sure that all people can understand the public health measures that the California Health Department is

implementing. The Public Health Department needs to research what the public wants to hear and how to transfer the information to them (Tembreull & Schaffer, 2005). It should be fun and stay away from lecture types of presentations (Tembreull & Schaffer, 2005).

To combine both the population demographics along with public participation, the Public Health Department should table and plan activities for farmer's markets, concerts, or church gatherings because these types of events have high attendance that do not require additional effort from the organizers. At these events, people can interact with volunteers at the WNV information booth and can sign up for a text message that updates the public once a week about WNV infection cases. The public health department can also use volunteers to walk around the events to pass out gifts such as sunscreen or long sleeve shirts that educate the public about WNV or provide QR codes to their website. These types of activities engage the target audience and plans for active participation (Tembreull & Schaffer, 2005).

Conclusion

Overall, California West Nile Virus cases have decreased significantly in the past years due to mosquito surveillance program and vector control efforts. Vector control efforts can be improved with less negative ecological impact with the use of genetically modified mosquitoes. Protecting the human and domestic animal populations can be done by finalizing an FDA approved vaccine and implementing mass vaccination programs in high risk areas. Public health education and outreach can be greatly improved by innovative ways to give information to everyone. With a continued effort to control infections and transmission, West Nile virus can be eliminated from California.

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