Chapter 31
Exploring the Spread of Zika:
Using Interactive Visualizations to Control Vector-Borne Diseases

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ABSTRACT

Vector-borne diseases pose a major public health threat. Combined, these diseases contribute significantly to illness and mortality worldwide and have an adverse impact on development and economic growth of nations. Public health stakeholders seeking to control and prevent these diseases are confronted with a myriad of challenges. Some of these difficulties are related to the nature of the data, the uncertainty of disease dynamics, and volatility of human-environment interactions. Visualization tools are capable of ameliorating some of these challenges. In this paper, the authors demonstrate how interactive visualizations can support stakeholders' decision-making tasks. In particular, they present a visualization tool they created that can support control efforts related to the recent Zika outbreak in Brazil.

1. INTRODUCTION

Vector-borne diseases (VBDs), such as zika, malaria, and dengue fever, do not respect geopolitical boundaries, as evidenced by their prevalent spread across the globe. For example, for the first time in history, Chikungunya, a disease endemic in African and South Asian countries, is now present in Caribbean nations (Charrel, Leparc-Goffart, Gallian, & de Lamballerie, 2014). Vector-borne diseases are a major public health threat which results in over 750 thousand deaths each year (World Health Organization, 2012). VBDs increase health inequities, put a strain on health services, and negatively impact development and economic growth (Campbell-Lendrum et al., 2015; World Health Organization, 2012). In full

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awareness of the consequences of VBDs, public health (PH) stakeholders[1] have implemented various preventive, control, and treatment measures. While substantial progress has been made, there is still much more that can and should be done.

To control VBDs, PH stakeholders must make sense of the epidemiological and entomological data, analyze the local determinants of the disease, compare possible vector-control methods, predict morbidity levels so as to ensure sufficient supply of treatment measures, and perform various other decision-making tasks. While engaged in these tasks, PH stakeholders interact with data[2]. This data has high volume, has extensive variety, and, in some situations, has low veracity (Eisen & Eisen, 2011; World Health Organization, 2012). These factors all contribute to the complex situation in which PH stakeholders operate to address VBDs. In addition to the challenges data presents, the multivariate nature of VBD poses additional obstacles to PH stakeholders. These challenges include understanding the complicated dynamics, interdependencies, and uncertainties that arise from various control strategies over time, and the impact of human-environment interaction on vector populations (Kramer et al., 2009). As with all infectious diseases, time plays a crucial role; the early detection of VBD outbreaks is essential to their control. When dealing with VBDs, the stakes are high, the challenges are immense, and a timely response is paramount. Therefore, computational tools that support the decision-making tasks of PH stakeholders are much needed. Fortunately, technological advances can dramatically change our capacity to predict, prevent, and control VBDs.

Interactive visualization tools (henceforth simply referred to as visualization tools without the adjective 'interactive') are a group of computational tools that has gained prominence in several disciplines over the last 20 years. These tools use interactive visual representations to convey information and support decision-making tasks by allowing users to control the flow of information, customize visual representations, and, in certain cases, perform other analytical tasks (Parsons & Sedig, 2014). Visual representations encode abstract or concrete information (e.g., geographic, scientific, or health data) in a visual form, and can be static or interactive. From the time Seaman used spot maps to study yellow fever in 1796 to the use of atlases to make sense of the endemicity of malaria in recent times, static visual representations have been used by PH stakeholders (Stevenson, 1965; Le Sueur et al., 1997). Though useful, static representations do not effectively support data-intensive tasks in which stakeholders engage. Visualization tools, on the other hand, employ the use of interactive visual representations and, as a result, are better equipped to support the decision-making tasks of stakeholders.

Since VBDs decision-making requires PH stakeholders to reason with heterogeneous data, visualization tools can play a major role. The effective and efficient use of data determines the extent to which PH stakeholders can sufficiently address VBDs (Reeder, Revere, Hills, Baseman, & Lober, 2012; Thomsen et al., 2016). Therefore, tools that allow users to interact with information systematically can support the decision-making process. Visualization tools include Spatio-Temporal Epidemiological Modeller (Ford, Kaufman, & Eiron, 2006), Panviz (Maciejewski et al., 2011), and Google Flu Trends (Carneiro & Mylonakis, 2009). An awareness of the potential of these tools is needed so as to facilitate their incorporation into PH practice. To this end, this article will focus on how visualization tools can support PH stakeholders make better decisions when dealing with VBDs.

The rest of this article is organized as follows. Section 2 presents visualization tools through a discussion of their characteristics and functionalities. Section 3 highlights challenges facing stakeholders as they engage in decision-making tasks and explains how visualization tools can address them. Section 4 presents a visualization tool we developed to support making sense of the recent Zika outbreak in Brazil. Section 5 provides a summary.