

Chapter 70

Using Volunteered Geographic Information to Assess the Spatial Distribution of West Nile Virus in Detroit, Michigan

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ABSTRACT

West Nile Virus is a vector-borne flavivirus that affects mainly birds, horses, and humans. The disease emerged in the United States in 1999 and by 2001 had reached Michigan. In clinical human cases, the most common symptoms are fever, weakness, nausea, headache, and changes in mental state. The crow is the most common wildlife host in the life cycle of the virus. The state of Michigan, through the Michigan Department of Community Health, collected the spatial locations of over 8,000 dead birds (Corvidae), statewide, during 2002. The large number of samples made spatial and temporal hotspot detection possible. However, the volunteer reporting method produced a dataset with a direct correlation between the numbers and locations of the dead birds and human population density and accurately identifying hotspots remains a challenge. Geographic variation in dead bird intensity was modeled using both global and local spatial clustering algorithms. Statistical models identified overall spatial structure and local clustering. Identification of hotspots was confounded by limited information about the collection procedures, data availability and quality, and the limitations of each method.

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INTRODUCTION

West Nile Virus (WNV) is a vector-borne RNA flavivirus that affects mainly birds, horses, and humans (Anderson, Vossbrinck, Andreadis, Iton, Beckwith, 2001). This paper considers the spatial distribution of West Nile Virus across a major metropolitan region from a medical geography perspective, which is concerned with the relationship between diseases and their spatial contexts. Examination of the timing and geographic locations of disease cases, as well as their environmental and social settings, can lead to identification of patterns and associations among the individual events together with key covariates. These associations may reflect underlying environmental influences and lead to greater understanding about the factors and drivers affecting the transmission and geographic diffusion of a disease, greatly facilitating the response of public health officials. An important innovation in medical geography is the development of statistically-driven hot spot detection methods (Anselin, 1995; Fotheringham & Zhan, 1996; Openshaw, 1996). Such methods are typically employed when extensive and often exhaustive, high-accuracy spatial data on disease are available (Ozdenerol, Bialkowska-Jelinska, Taff, 2008). Frequently, secondary demographic datasets are employed to model the population at risk, thereby accounting for spatial variation in that background population and helping identify anomalous hot spots (Cooke, Katarzyna, Wallis, 2006).

In contrast to the contexts of previous studies with highly accurate and extensive data, this paper is concerned with the employment of volunteered geographic information in the analysis and detection of hot spots. The term, "volunteered geographic information," (VGI) is used to indicate data that are measured and reported by the public. The accuracy and completeness of such data may be quite variable; in some cases, it may be more reliable than authoritative sources (Goodchild, 2008), especially in periods of rapid and critical change such as natural or human disasters. For

example, during a wildfire, a cell phone equipped person on the spot may be in a much better position to inform the public about local conditions. Important advantages of VGI in the context of this paper include cost-efficiency, timeliness, and citizen engagement with public health issues. However, its utility for subsequent spatial analysis may be questionable due to biases and data quality concerns.

Focusing on data collected during the 2002 WNV epidemic in southeastern Michigan, USA, this paper explores two related research questions.

1. Are volunteered geographic health data suitable for use in statistical spatial hot spot detection applications?
2. Assuming that the previous question is true, then during the 2002 WNV epidemic in Michigan, did spatial or temporal clusters emerge that might be indicators of future risks?

The remainder of this introduction provides important background on WNV, its spread in southeastern Michigan, and the surveillance methods employed there. Then it considers the nature of available VGI for the epidemic in this region. It identifies critical uncertainties in the available information that limit the kinds of questions that can be asked and conclusions that can be drawn. The paper continues by discussing data processing, including geocoding, which is a critical operation for using VGI, and describes the spatial hotspot detection methods used in the research. We then report our findings, and discuss what those findings actually indicate about the spatial and temporal spread of WNV across the Detroit metropolitan area in 2002.

WEST NILE VIRUS

In 1999, WNV became an endemic disease in the Western Hemisphere. The disease was first iden-

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