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A space time analysis evaluating the impact of hurricane sandy on HIV testing rates

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ABSTRACT

Spatial proximity to infrastructural damage from natural disasters may pose a threat to established HIV testing services and contribute to delays in knowledge of one's disease status. Physical vulnerabilities such as spatial proximity to a level 4 FEMA impact zone, are defined in this study as natural and infrastructural barriers that can impede access to care. We analyzed the storm effects and community characteristics that contributed to the changes in HIV testing rates post Hurricane Sandy. Univariate and bivariate Moran's I tests were conducted to test for spatial autocorrelation. Combined spatial lag and error models accounted for lagged effects and alternatives in error distribution. Bivariate local Moran's I identified many significant clusters of more extreme negative relative change in HIV testing rates in areas with high FEMA impact ranks. Spatial lag and error models highlighted a significant relationship between CBSAs closer to a level 4 FEMA impact zone and the increased effect of Hurricane Sandy on HIV testing. Additionally, as the number of habitable buildings increased, there was significantly less change in HIV testing rates. Physical vulnerability had a significant effect on HIV testing rates. However all findings became less significant over time, highlighting the recovery process. Factors including: increased communication concerning preventative measures prior to the disaster, a prompt response to mitigate infrastructural damage and resumption of HIV testing services, are essential at the government and community levels to mitigate infection risk.

1. Introduction

In late October of 2012, Hurricane Sandy made landfall, killing 73 people in the United States and causing damage to homes, businesses and infrastructure systems [1,2]. Disasters can increase risk behaviors, lead to changes in social and sexual networks that adversely impact health, cause migration or displacement and impact resources [3]. These changes can threaten HIV testing and prevention strategies [4]. Almost 14% of people with HIV do not know their status and can unknowingly spread the disease to others. HIV testing, status confirmation, and prompt access to care are strategies to reduce disease burden and morbidities associated with the progression to AIDS [5]. Overall test and treat policies put in place in 2010 have reduced HIV incidence by 7%, and the mortality rate associated with HIV has decreased by 30% [4]. However, during natural or man-made disasters, HIV testing services may be at risk for interruption.

Natural disasters create impact across individual, social, and environmental scales that can contribute to these declines in testing. These disasters can lead to a lower perceived risk of non-emergent health needs and may increase risk behaviors (e.g., increase in unprotected sex risk and/or injection behaviors), lead to changes in social and sexual networks, cause individuals to de-prioritize preventive services, result in population changes (ex. migration), and impact a community's self-efficacy [6]. Additionally, disasters affect a community's ability to mobilize resources and result in infrastructure damage [7,8]. These post-event changes pose a threat to established HIV testing and

Abbreviations: HIV, Human Immunodeficiency Virus; FEMA, Federal Emergency Management Agency; CDC, Centers for Disease Control and Prevention; SVI, Social Vulnerability Index; CBSA, Core Based Statistical Areas; SIA, Sandy Impact Area; ITS, Interrupted time series analysis; OLS, Ordinary least squares; FEMA MOTF, Federal Emergency Management Agency Modeling Task Force; HSIA, Hurricane Sandy Impact Area

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prevention strategies and can contribute to disease spread. Therefore, it is essential to examine the impact of Hurricane Sandy on HIV testing rates [8,9].

The concept of vulnerability research aims to establish a multi-faceted approach to understanding disaster scenarios. Disasters can no longer be defined as solely natural events and are better regarded in the context of "a society, its infrastructure, economy and environment" [7]. Thus the risk of testing interruption may be heightened by the vulnerabilities of the region. A community is physically vulnerable on the basis of its physical geography and in addition the added anthropogenic, infrastructural vulnerability of the area [7]. Research on hazard and disaster vulnerability has historically focused on physical vulnerability rather than the more difficult to quantify social vulnerability [10]. Both physical and social vulnerability data represents important factors that inform on a community's vulnerability to disasters. This study explores the change in HIV testing rates across a 12 week period post Hurricane Sandy. In order to understand the additional burdens communities face in recovering from a natural disaster it is important to consider community level social vulnerability in addition to physical vulnerability [9]. Social vulnerability goes beyond the socio-economic status, race and insurance status of an individual and reflects the community's ability to prepare for and recover from disasters. This is in contrast to vulnerability based solely on the physical and built environment [10,11]. The extant literature indicates disasters are more likely to adversely affect the socially vulnerable [12–15]. These communities have less ability to take precautions before hazards occur and recover more slowly and not completely in the aftermath [10,11,16–19].

Here we apply spatial methodologies that incorporate physical vulnerabilities to assess rates of HIV testing of insured individuals across time and space. Repeated analyses across the weeks attempt to illustrate the recovery process after Hurricane Sandy and identify spatial variables correlated with a drop in testing rates. Further, we explore the association between FEMA impact zone levels and social vulnerability scores to better characterize the relationship of community level social and physical vulnerabilities.

2. Theory

This analysis explores the physical and social vulnerabilities pre and post-natural disaster affecting access to HIV testing services in a spatial context. Tobler's first law states that "everything is related to everything else, but near things are more related than distant things" [20]. FEMA impact zones of natural disasters often show high spatial autocorrelation. However, additional factors such as physical vulnerability can complicate health outcomes. Wisner suggests: "Social, economic, and political conditions [are] required to turn the hazard into a disaster" [21]. Combining spatial and social theories will better determine how these variables contribute to emergency response in disaster settings.

3. Methods

3.1. Data Sources

Data for this analysis was obtained from the Federal Emergency Management Agency Modeling Task Force (FEMA), the Centers for Disease Control and Prevention (CDC) and Truven Health Analytics [22,23]. Truven Health MarketScan is a health insurance claims database compiled from enrollees with employer-sponsored private health insurance including employees, retirees, and dependents. Data are representative of the United States' privately insured population [22,24]. The database includes paid claims as well as detailed patient information. The specific databases within MarketScan used to obtain the target population for this study were the Commercial Claims and Encounters Database (CCAE); and Medicare Supplemental and Coordination of Benefits Database (MDCR). The population of interest in this study is privately insured individuals (enrollees) residing in the Hurricane Sandy Impact Area (HSIA), not identified as having an HIV diagnosis.

Our outcome of interest was the change in HIV testing rates for 12 weeks following Hurricane Sandy. This analysis was performed at the core based statistical area (CBSA) as the unit of analysis. CBSAs are a geographic area that consists of one or more counties with a core urban population of at least 10,000 and neighboring counties that are socio-economically tied to that urban center through commuting [25]. There were a total of 90 CBSAs used in this study. Explanatory variables included in the analysis were percent of buildings left habitable and households damaged per CBSA, HIV prevalence pre Hurricane Sandy per CBSA and the minimum distance to a FEMA level 4 impact zone. Initially we had hoped to include the CDC's Social Vulnerability Index (SVI) to assess the impact of social vulnerability on the change in testing rates. The SVI is an publically available index (www.svi.cdc.gov) which uses percentile ranking to combine fifteen census-based socio-demographic variables resulting in a value between 0 and 1 [26]. This index was originally created by Flanagan et al., 2011 and a detailed description of the construction of the index in provided in their text [10]. However the outcome dataset utilizes private insurance based data only thus is not representative of the entire population, especially the most vulnerable. The SVI is instead utilized in the spatial analyses to explore the association between FEMA impact zones and social vulnerability scores. This exploration attempts to illustrate the importance of social vulnerability in practice-oriented research despite dataset limitation. A detailed description of all the specific variables used in this analysis can be found in Table 1.

Table 1
Description of variables used in analysis.

	VARIABLE	SCALE	TIME PERIOD	DESCRIPTION	SOURCE
Outcome	Change in HIV testing rates post Hurricane Sandy	CBSA	5 time points: October 22–29, 2012 (0), and 1, 4, 8, and 12 weeks post-event.	Interrupted Time Series models were used to calculate relative change in weekly HIV testing rates as the outcome of interest. This variable was rescaled in this analysis by a factor of 100 from 0.28 to 2.00–28.00–200.00 for interpretability in the modeling phase.	[22]
Controls	HIV pre prevalence	CBSA	Baseline data from Jan 1, 2011 until time 0	The prevalence of HIV prior to Hurricane Sandy was averaged over time from Truven data for each CBSA.	[22]
Physical Vulnerabilities	Households damaged	CBSA	October 22–29, 2012	Provide by FEMA, this variable calculated the percentage of all homes in the CBSA that were damaged or lost during the time frame of Hurricane Sandy.	[23]
	Building retention	CBSA	October 22–29, 2012	Provide by FEMA, this variable calculated the percentage of all building in the CBSA that remained habitable post event.	[23]
	Distance	CBSA	NA	Utilizing CBSA centroids, the distance between each CBSA and every CBSA that was deemed a level 4 zone was calculated. Minimum distances from each CBSA to a level 4 zone were selected.	[23]

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