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Short Communication

A comparison of the geographic patterns of HIV prevalence and hurricane events in the United States

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ABSTRACT

Objectives: Previous research has documented the adverse association between hurricanes and HIV health outcomes; however, no research has been conducted to examine whether there is spatial overlap between hurricane events and the epidemiology of HIV in the United States. The objectives of this study were to assess the geographic distributions of and spatial autocorrelation between HIV prevalence and the occurrences of hurricanes in the US.

Study design: This was a cross-sectional study.

Methods: Data on HIV prevalence rates were obtained from the Centers for Disease Control and Prevention, and data on US hurricane events were obtained from the National Oceanic and Atmospheric Administration. ArcGIS, version 10.6, was used for mapping HIV prevalence rates and occurrences of hurricane events, and GeoDa, version 1.12, was used to conduct all univariate and bivariate spatial autocorrelation analyses.

Results: HIV and hurricanes primarily affected states located in the south and along the Gulf Coast. Major hurricanes were reported among these regions also. States recording 20 or more hurricanes between 1851 and 2017 had an average HIV prevalence rate of 453.2 cases per 100,000 in 2016. States recording five or more major hurricanes between 1851 and 2017 had an average HIV prevalence rate of 421.8 cases per 100,000 in 2016. Regarding univariate spatial autocorrelation, HIV prevalence was clustered (Moran's *I*: 0.1913; pseudo *P*-value: 0.003). Hurricane events were also clustered (Moran's *I*: 0.2826; pseudo *P*-value: 0.004), as were major hurricanes (Moran's *I*: 0.1982; pseudo *P*-value: 0.009). There was statistically significant bivariate spatial autocorrelation between neither HIV and hurricanes nor HIV and major hurricanes.

Conclusion: The epidemiology of HIV prevalence and hurricane events has overlapping geographic patterns. This may have implications for hurricane readiness and recovery planning with respect to people living with HIV.

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Introduction

Previous studies have established that severe hurricane events contribute to negative health effects among people living with HIV (PLWH),[1–3] disruption of HIV medication regimens,[2,4,5] and impedance of usual HIV care services.[4,6,7] Although this adverse association between HIV outcomes and hurricane disasters has been studied, research has not been conducted to investigate the spatial overlap between hurricane events and the epidemiology of HIV. Therefore, this study sought to examine the geographic distributions of hurricane events and HIV prevalence in the USA. This study also aimed to assess spatial clustering of HIV, hurricanes, and major hurricane events. Finally, this study sought to determine whether there was evidence of dual spatial clustering between HIV and hurricanes, as well as HIV and major hurricanes. Such research would help to inform where PLWH may be most at risk of experiencing poor health outcomes and interruptions in HIV care due to encountering severe hurricane weather. Findings from this study may also contribute to improved hurricane readiness and response planning for PLWH residing in hurricane-prone areas.

Methods

The study area of interest was the contiguous US. This study utilizes data on HIV prevalence rates (per 100,000 population) by US and the District of Columbia from the National Center for HIV/AIDS, Viral Hepatitis, STD, and TB Prevention at the Centers for Disease Control and Prevention (CDC).[8] The data represent the HIV prevalence among individuals aged at least 13 years living with diagnosed HIV infection as of December 31, 2016. Cumulative data on historical hurricane events in the US between 1851 and 2017 were obtained from the second-generation hurricane database (HURDAT2) established by the National Hurricane Center of the National Oceanic and Atmospheric Administration.[9] The HURDAT2 database includes information on landfalling hurricane direct hits to individual states and the coastline of the US mainland. This data set also includes information on major hurricanes, which are defined as category 3, 4, or 5 hurricanes based on the Saffir/Simpson Hurricane Scale. All data included in the analyses for this study were de-identified, state-level aggregated, and publicly available in US government databases.

To examine geographic distributions, the mapping of HIV prevalence rates and occurrences of hurricane events by state was visualized in the Geographic Information System software using quantile classification. To assess the presence of spatial clustering, univariate Moran's *I* analyses were conducted for HIV prevalence and hurricane events in the US. The univariate Moran's *I* analysis was also conducted for data on major hurricanes. In addition, bivariate Moran's *I* analyses were used to measure the spatial autocorrelation between the rate of prevalent HIV cases for a state with the occurrences of hurricane events and, then, major hurricane events in adjacent states. All Moran's *I* analyses were conducted using row standardization, first-order queen contiguity spatial weights, and 999 permutations for statistical significance inference. A Moran's *I* of approximately 0.2 or greater was regarded as highly clustered.[7] All mapping of HIV prevalence and hurricane events was conducted using ArcGIS, version 10.6, (Environmental Systems Research Institute Inc., Redlands, CA, USA). All spatial analyses were conducted in GeoDa, version 1.12, (University of Chicago, Chicago, IL, USA).[10]

Results

The geographic distributions of HIV prevalence and hurricane events occurring in the US are presented in Fig. 1. Hurricanes primarily affected southern states and states along the Gulf Coast, with hurricane events occurring with less frequency among states on the upper east coast and in the northeastern region of the US. The states of Florida, Louisiana, North Carolina, and Texas had the greatest number of direct hurricanes between 1851 and 2017 with 120, 54, 55, and 64 hurricanes, respectively. South Carolina, Alabama, Georgia, and Mississippi recorded 30, 24, 22, and 19 hurricanes, respectively, over the time period. Louisiana, Texas, and Florida also had the greatest number of major hurricanes of all states with 17, 19, and 37, respectively. See Table S1 for additional hurricane event information.

Aside from along the west coast and in the northeast, the epidemiology of HIV was mostly prevalent among Gulf Coast states and states in the south, similar to hurricane events. Florida reported a rate of 610.8 HIV cases per 100,000 in 2016. Georgia had an HIV rate of 602.4 cases per 100,000, and Louisiana reported a rate of 517.8 cases per 100,000. Alabama, Texas, Mississippi, and the states of North Carolina and South Carolina reported high HIV prevalence rates between 300 and 400 cases per 100,000. States that recorded 20 or more hurricane events between 1851 and 2017 had, on average, an HIV prevalence rate of 453.2 cases per 100,000, which is greater than the national average of 365.5 HIV cases per 100,000 in 2016.[8] States with five or more major hurricanes over the time period had, on average, 421.8 HIV cases per 100,000, which also exceeds the HIV prevalence rate for the US. See Table S1 for further descriptive statistics on HIV prevalence.

In Fig. 1, the epidemiology of hurricanes and HIV appeared to be spatially clustered, which was confirmed by results from the spatial autocorrelation analyses as shown in Fig. S1. The univariate Moran's *I* for HIV prevalence was found to be 0.1913 (Z-value: 3.46; standard deviation: 0.0617; pseudo *P*-value: 0.003). The univariate Moran's *I* for hurricane events in the US was reported to be 0.2826 (Z-value: 3.83; standard deviation: 0.0797; pseudo *P*-value: 0.004). It was found that the bivariate Moran's *I* for the spatial distribution between HIV prevalence and hurricane occurrences was 0.1128 (Z-value: 1.58; standard deviation: 0.0751; pseudo *P*-value: 0.078) (Fig. S2). In addition, the univariate Moran's *I* for major hurricane events was 0.1982 (Z-value: 3.13; standard deviation: 0.0709; pseudo *P*-value: 0.009). The bivariate Moran's *I* for the spatial autocorrelation between HIV prevalence and the occurrence of major hurricanes was 0.0527 (Z-value: 0.782; standard deviation: 0.0742; pseudo *P*-value: 0.158) (Fig. S2).

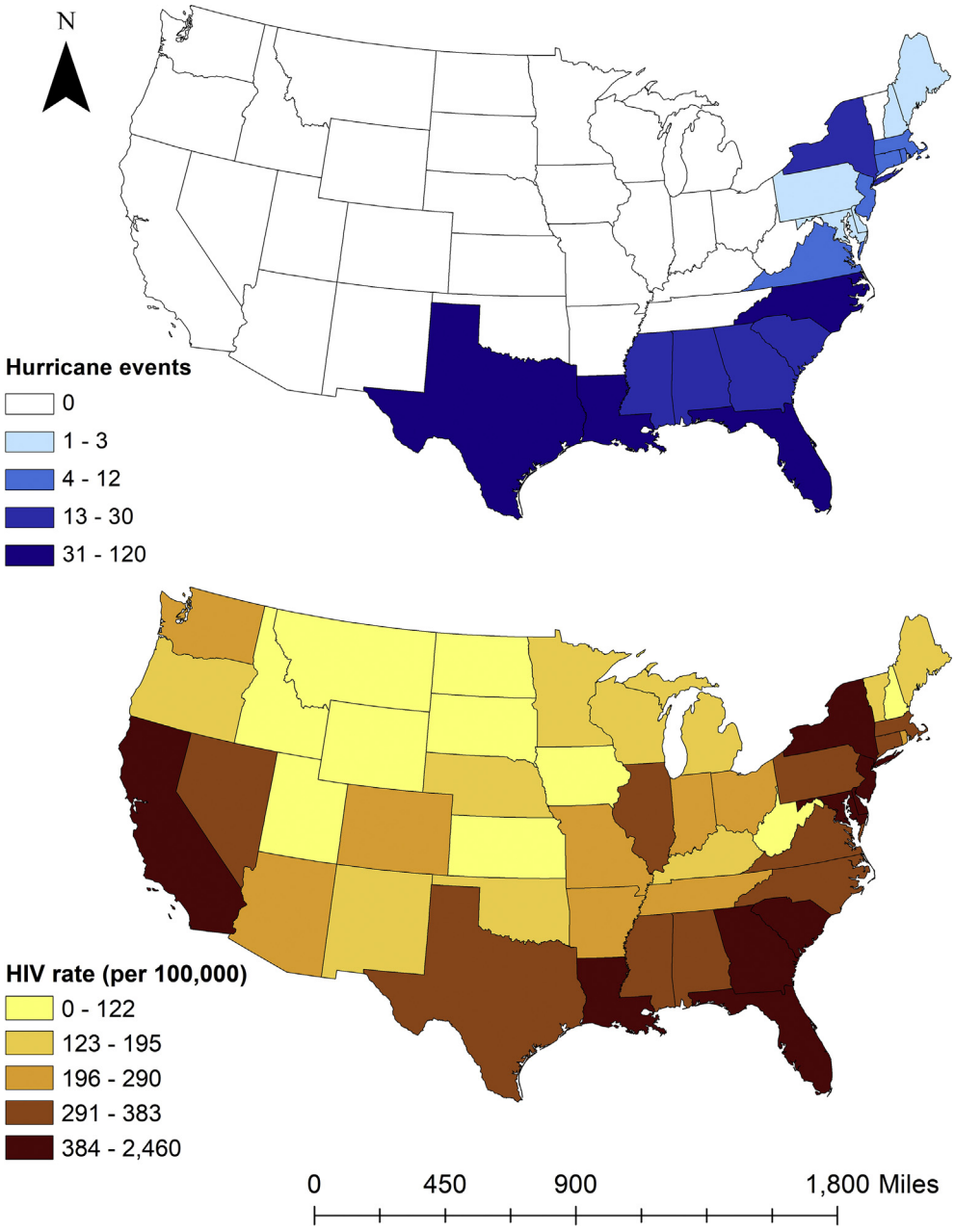

Fig. 1 – Top panel: Geographic distribution of hurricane events per state for the contiguous United States, 1851–2017; Bottom panel: Geographic distribution of the HIV prevalence rate (per 100,000 population) per state for the contiguous United States, 2016.

Discussion

In this study, we found that the epidemiology of HIV prevalence and hurricane events have overlapping geographic patterns that may have implications for hurricane preparedness and response planning regarding PLWH. Geographically, both HIV and hurricanes affected states that were largely located in the south and on the Gulf Coast. Major hurricanes were reported primarily among these regions also. States with more recorded events of hurricanes, and also major hurricanes, had higher HIV prevalence rates than that reported for the US. Moreover, rates of prevalent HIV cases, hurricane events, and major hurricanes were each significantly and highly clustered. The spatial autocorrelation between HIV prevalence and hurricane events was moderately clustered, although not statistically significant, and there was no spatial autocorrelation between HIV prevalence and major hurricanes. These results indicate that there is potential widespread exposure to severe hurricane weather for populations of PLWH, which may contribute to adverse health outcomes and disrupted health care for such an already-vulnerable group. The findings of this study are crucial to understanding where PLWH may experience an exacerbation of

vulnerability and poor health due to hurricanes, which can help to guide public health preparedness and response efforts with regard to PLWH and HIV care services.

Limitations of this study should be addressed to strengthen future studies. First, this study exclusively evaluated hurricane data and HIV data at the state level. There may be more informative spatial patterns and variation at more specific geographic scales, such as at the county level. Conducting future studies in this area using data at finer geographic levels can provide useful findings that may be essential for developing targeted disaster preparedness and response interventions in more localized areas. Second, the most recent data on HIV prevalence reported by the CDC date back to 2016; therefore, the results on HIV prevalence rates may be underestimates or overestimates, contingent upon state-level trends of HIV prevalence since 2016. In addition, the hurricane data may be underestimated because the HURDAT2 database does not capture hurricane occurrences earlier than 1851. Finally, this study uses cumulative hurricane event data from the period of 1851–2017, without evaluating specific years or months. Therefore, we cannot ascertain any spatiotemporal trends between hurricane occurrences and HIV prevalence in the present study, which may dually highlight areas and times of the year during which PLWH may be most exposed to severe hurricane weather.

In conclusion, southern and Gulf Coast states are the most exposed regions to hurricane weather events in the US, and the epidemiology of HIV prevalence is similarly prevalent among these areas. It was found that states with a higher record of hurricane events, and also major hurricanes, reported higher rates of HIV prevalence compared with national levels. This has implications for public health preparedness and response efforts regarding hurricane readiness and recovery for PLWH. This research may help public health and disaster management professionals consider the vulnerability of PLWH within their regions to future hurricanes. This study may also inform hurricane preparedness interventions for populations of PLWH and mitigation plans for HIV care centers and clinics in hurricane-prone areas. In conclusion, considering the adverse association between hurricanes and HIV health outcomes and delivery of care, the evident geographic overlap between HIV and hurricane occurrences in the US may need to be addressed in future public health research and practice with respect to PLWH.

Author statements

Ethical approval

The institutional review board approvals were not required as no human beings were involved in this research.

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Competing interests

The author declares no competing interests.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.puhe.2019.04.001.