Type II diabetes emergency room visits associated with Hurricane Sandy in New Jersey: implications for preparedness

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Abstract:

On October 29, 2012, Hurricane Sandy made landfall in New Jersey, causing major power outages, flooded roads, and disruption of public transportation. Individuals diagnosed with diabetes may be especially vulnerable to natural disasters because of limited access to medications or use of glucose monitoring devices. We examined changes in emergency room visits (ERVs) for type II diabetes mellitus potentially associated with Hurricane Sandy in New Jersey. Data analyzed in 2014 included ERVs to general acute care hospitals in New Jersey among residents of three counties with a primary or secondary type II diabetes diagnosis (PDD or SDD) in 2011–2012. Compared to the previous year, results showed an 84% increased rate of PDD ERVs during the week of Hurricane Sandy, after adjusting for age and sex (rate ratio (*RR*) = 1.84, 95% confidence interval (*CI*) 1.12, 3.04). Results were nonsignificant for SDD (*RR* = 0.94, 95% *CI* 0.83, 1.08). Spatial analysis showed the increase in visits was not consistently associated with flood zone areas. We observed substantial increases in ERVs for primary type II diabetes diagnoses associated with Hurricane Sandy in New Jersey. Future public health preparedness efforts during storms should include planning for the healthcare needs of populations living with diabetes.

Keywords: diabetes mellitus | Hurricane Sandy | emergency preparedness | type II diabetes | New Jersey

Article:

*****Note: Full text of article below**

Type II Diabetes Emergency Room Visits Associated With Hurricane Sandy in New Jersey: Implications for Preparedness

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Abstract **On October 29, 2012, Hurricane Sandy made landfall in New Jersey, causing major power outages, flooded roads, and disruption of public transportation. Individuals diagnosed with diabetes may be especially vulnerable to natural disasters because of limited access to medications or use of glucose monitoring devices. We examined changes in emergency room visits (ERVs) for type II diabetes mellitus potentially associated with Hurricane Sandy in New Jersey. Data analyzed in 2014 included ERVs to general acute care hospitals in New Jersey among residents of three counties with a primary or secondary type II diabetes diagnosis (PDD or SDD) in 2011–2012. Compared to the previous year, results showed an 84% increased rate of PDD ERVs during the week of Hurricane Sandy, after adjusting for age and sex (rate ratio (*RR*) = 1.84, 95% confidence interval (*CI*) 1.12, 3.04). Results were nonsignificant for SDD (*RR* = 0.94, 95% *CI* 0.83, 1.08). Spatial analysis showed the increase in visits was not consistently associated with flood zone areas. We observed substantial increases in ERVs for primary type II diabetes diagnoses associated with Hurricane Sandy in New Jersey. Future public health preparedness efforts during storms should include planning for the healthcare needs of populations living with diabetes.**

Introduction

Type II diabetes mellitus is a leading cause of death and disability in the U.S. (Centers for Disease Control and Prevention [CDC], 2011). Diabetes is a serious chronic health condition that if not properly managed and monitored can lead to health complications and mortality. As diabetes incidence increases, this subpopulation becomes especially vulnerable to disasters and climate change (Cook, Wellik, & Fowke, 2011) because they may require special health monitoring devices and regular medication intake. Improper emergency preparedness during disasters can lead to inappropriate medication storage or a lack of extra battery supplies for monitoring equipment and other devices necessary for appropriate diabetes control (Cefalu, Smith, Blonde, & Fonseca, 2006).

Few studies have examined if natural disasters are associated with increases in diabetes-related visits or hospitalizations during the natural disasters. One study reported aggravated glycemic control due to increased stress after a disaster among populations diagnosed with diabetes (Inui et al., 1998). Fonseca and co-authors (2009) reported a significant adverse effect on diabetes management, resulting in both negative health and economic implications, after Hurricane Katrina. Patient hemoglobin A1C levels, for example, postdisaster increased significantly ($p < .001$). People with diabetes are also susceptible to experiencing cuts, burns, and amputations as a result of a natural disaster, and some previous studies have suggested increases in emergency room visits (ERVs) and hospitalizations related to accidental injury and trauma after hurricanes for individuals with diabetes (Brewer, Morris, & Cole, 1994; Ford et al., 2006; Platz, Cooper, Silvestri, & Siebert, 2007).

On October 29, 2012, Hurricane Sandy made landfall in New Jersey, causing major flooding (Jonkman, Maaskant, Boyd, & Levitan, 2009); power outages (Sakashita, Matthews, & Yamamoto, 2013; Seung-Ryong et al., 2008); and closures of community pharmacies (Traynor, 2012), roads, and public transportation. Hurricane Sandy caused 65% of utility customers in New Jersey to lose power (Trinacria, 2012) and the restoration of power to 95% of the population was reached only 11 days after the peak number of outages were reported (Siart, 2012). In New Jersey, the estimated age-adjusted diabetes prevalence for adults was 8.5% in 2010, an increase from 4.5% in 1995 (CDC, 2012). With hurricanes making landfall increasingly more often in the U.S., it is essential not only to document effects

TABLE **1**

Number of Weekly Emergency Room Visits (ERVs) for Type II Diabetes and Percent Change, 2011–2012

Primary Diabetes Diagnosis				
Week	**Number of ERVs**		**Absolute Difference**	**Percent Change**
	2011	2012		
October 1–7	34	26	-8	-23.5
October 8–14	29	24	-5	-17.2
October 15–21	42	33	-9	-21.4
October 22–28	38	30	-8	-21.0
October 29–November 4	**22**	**53**	**31**	**140.9**
November 5–11	35	33	-2	-5.7
November 12–18	29	28	-1	-3.4
November 19–25	37	39	2	5.4
November 26–December 2	23	30	7	30.4
December 3–9	32	29	-3	-9.4
December 10–16	39	37	-2	-5.1
December 17–23	39	25	-14	-35.9
December 24–30	23	22	-1	-4.4
Total of the remaining weeks	1,308	1,339		
Annual total	1,730	1,748		

Secondary Diabetes Diagnosis				
Week	**Number of ERVs**		**Absolute Difference**	**Percent Change**
	2011	2012		
October 1–7	467	473	6	1.3
October 8–14	483	510	27	5.6
October 15–21	481	481	0	0.0
October 22–28	497	517	20	4.0
October 29–November 4	**426**	**527**	**101**	**23.7**
November 5–11	484	484	0	0.0
November 12–18	472	452	-20	-4.2
November 19–25	442	448	6	1.4
November 26–December 2	467	479	12	2.6
December 3–9	494	442	-52	-10.5
December 10–16	499	463	-36	-7.2
December 17–23	457	439	-18	-3.9
December 24–30	507	466	-41	-8.1
Total of the remaining weeks	18,162	19,778		
Annual total	24,338	25,959		

Note: The data from the week Hurricane Sandy occurred are in bold.

of natural disasters on medical care and health outcomes, as previously described (Brewer, Morris, & Cole, 1994; Ford et al., 2006; Jonkman, Maaskant, Boyd, & Levitan, 2009; Platz et al., 2007; Seung-Ryong et al., 2008), but also to geographically map ERVs and determine if there are any spatial patterns of risk to prepare for more prompt and effective emergency clinical care and public health responses.

In this study, we investigated changes in ERVs associated with Hurricane Sandy, pre and postdisaster. There was a special interest to examine diabetes visits in Atlantic, Cape May, and Ocean counties due to their high diabetes prevalence, their spatial location on the Atlantic coast with relation to hurricanes making landfall, and because New Jersey residents did not have mandatory evacuation advisories, with the exception of Cape May County. Specific hypotheses of the study were: a) ERVs for type II diabetes diagnoses will be significantly higher after the arrival of Hurricane Sandy (October 29–December 31, 2012) compared with the same time period the previous year (October 29–December 31, 2011); b) there will be a significant change in the place of residence of patients diagnosed with primary and secondary diagnoses of type II diabetes after Hurricane Sandy, with the majority of cases emanating from flood zone areas after the hurricane; and c) after Hurricane Sandy, individuals who lived in socioeconomically disadvantaged places of residence (i.e., neighborhood of residence) will have a greater number of ERVs for type II diabetes care than those living in more affluent places.

Methods

Study Design

This study was a retrospective analysis of ERV records before and after Hurricane Sandy. Data were extracted from New Jersey Department of Health's (NJDOH) Uniform Bill emergency department discharge data files. This study was approved by the Rutgers Institutional Review Board.

Study Settings and Population

The study population included adults in New Jersey who resided in Atlantic, Cape May, and Ocean counties and who had an ERV at a general acute care hospital in New Jersey during 2011 and 2012. We assessed patients with PDD or SDD not admitted for hospitalization after having been in the emergency room.

Outcomes

Diagnosis was based on the *International Classification of Disease, 9th Revision, Clinical Modification* [ICD-9-CM] (Medicode, 1996). We included ERV with type II primary and/or secondary diabetes diagnosis (i.e., ICD-9-CM codes 250.x0 or 250.x2).

Exposure

Our main interest was to compare the time period during the week of Hurricane Sandy, October 29–November 4, 2012, with the same period of the previous year, October 29–November 4, 2011. Further, we examined trends across various time periods in an attempt to capture changes due to seasonal trends. The time periods were divided into weekly segments before and after the week of Hurricane Sandy. The four time periods immediately prior to the hurricane included October 1–October 7, October 8–October 14, October 15–October 21, and October 22–October 28. The nine periods of and after the week of the hurricane included October 29–November 4, November 5–November 11, November 12–November 18, November 19–November 25, November 26–December 2, December 3–December 9, December 10–December 16, December 17–December 23, and December 24–December 30.

Flooding zone data for New Jersey were acquired from the U.S. Federal Emergency Management Agency (FEMA), Region II, Coastal Analysis and Mapping. Flood hazard data were used to geographically map flood zones to compare municipality level ERV rates pre-Sandy during the week of October 29–November 4, 2011, with the week of October 29–November 4, 2012 (week of Hurricane Sandy).

TABLE **2**

Type II Diabetes Emergency Room Visit (ERV) Demographics by Year: Three New Jersey Counties, Week of Hurricane Sandy, 2011–2012

Demographics	2011		2012	
	Primary Diabetes Diagnoses	Secondary Diabetes Diagnoses	Primary Diabetes Diagnoses	Secondary Diabetes Diagnoses
Hospital ERV characteristics				
Age, mean (*SD*)	55.1 (16.6)	60.4 (15.4)	60.3 (14.0)	64.0 (15.2)
Gender, %				
Male	77.3	50.9	66.0	50.7
Female	22.7	49.1	34.0	49.3
Race/ethnicity, % (*n**)				
Hispanic/Latino	9.5	4.5	3.6	2.2
Non-Hispanic Black	38.1	14.7	3.6	7.4
Asian, Non-Hispanic	0	2.3	0	1.1
Multiracial/Other, Non-Hispanic	4.8	1.8	0	2.5
Non-Hispanic White	47.6	95.7	92.9	87.0
Neighborhood characteristics				
Municipal poverty, %				
0–10	45.45	71.6	52.8	70.2
11–20	9.10	6.3	13.2	5.7
21–40	45.45	22.1	34.0	24.1

**Note:* Numbers <5 not presented to preserve patient confidentiality.

Potential Confounders

Data on potential confounders available for the present study included age, sex, race, and ethnicity, plus county and municipality of residence. Age was grouped into 20–34 years, 35–49 years, 50–64 years, 65–79 years, and 80+ years. Race was categorized as non-Hispanic White; non-Hispanic Black; Asian, non-Hispanic; Multiracial and Other races, non-Hispanic; and Hispanic/Latino. Municipal-level poverty was grouped into 0–10%, 11–20%, and 21–40%.

Municipality-level poverty, as an indicator of socioeconomic status, was obtained from U.S. Census American Community Survey 2006–2010, Selected Population Tables (DP03) by county subdivisions. The variable examined was the percentage of families whose income in the past 12 months fell below the federal poverty level.

Data Analysis

Geographical Analysis and Mapping

ERV data were linked, using county and municipality codes, to Federal Information Processing Standard (FIPS) codes. Patient data were merged with U.S. Census data using their FIPS code and geographical identification (GEO.ID2) The crude rate per 10,000 population was calculated by municipality for PDD and SDD using frequency of ERVs during the week of October 29–November 4 (in 2011 and in 2012) divided by municipality population. Rates were mapped using municipality boundaries and these maps were compared to FEMA flood zone boundaries to spatially identify the difference in ERV rates between the two years by municipality. Due to research staff limitations, we were not able to further determine which specific areas experienced actual flooding and how these areas compared to the flood zones designated by FEMA. This would have allowed us to determine how well emergency response planning corresponded to actual affected areas. Additionally, it should be noted how in each targeted county, the municipalities could be entirely in, partially within, or completely outside FEMA flood zones. Municipalities were defined as inside if they were completely inside the flooding area and outside if they were completely outside of the flooding area. Remaining municipalities were categorized as partially inside of

TABLE **3**

Number of Municipalities With Diabetes Emergency Room Visits Before and After Flooding (October 29–November 4)

Municipalities in Flood Zone Area	2011		2012	
	Primary Diabetes Diagnoses	Secondary Diabetes Diagnoses	Primary Diabetes Diagnoses	Secondary Diabetes Diagnoses
Atlantic County				
Inside	1	4	3	4
Partially inside	1	10	6	9
Completely outside	1	2	0	3
Cape May County				
Inside	0	1	2	2
Partially inside	1	4	1	5
Completely outside	0	1	1	1
Ocean County				
Inside	1	7	2	8
Partially inside	4	13	6	12
Completely outside	3	5	2	6

flooding area. Additionally, county maps with municipality divisions were used to spatially map the crude rate of type II diabetes ERVs before and after flooding (October 29–November 4, 2011 versus October 29–November 4, 2012, respectively). (Map not presented; other maps available upon request from the authors.)

Statistical Analysis

Descriptive statistics were calculated for PDD and SDD by weeks, months, and year. Analyses were performed using SAS Version 9.3 and ArcGIS 10.2. Comparisons included weeks and months of the previous year to determine the impact of the storm on ERVs and if observed differences could be due to seasonal trends. The count differences and percent changes were calculated by weeks. The distribution of sex, race, ethnicity, municipality-level poverty percentage, and age were calculated for PDD and SDD during the week of the hurricane in 2011 and in 2012 for residents of each county. We used distributed-lag Poisson generalized linear models to obtain rate ratios examining the association between the week of the hurricane event in 2012 compared with the same week in 2011 and the number of diabetes ERVs. Separate models were fit for PDD and SDD. Poisson distribution was used because it is considered appropriate for ERV count data. Model 1 represented the crude association in the change in number of ERVs for 2012 compared with 2011. Model 2 additionally adjusted for age and sex, and Model 3 added race and ethnicity. To determine if the change in ERVs differed by municipality poverty level, we re-coded the poverty variable into a three-level measure (≤10%, 11–20, and ≥21%). We stratified by this new poverty measure and re-ran Models 1 through 3. The models, however, did not converge due to small sample sizes between race/ethnicity and poverty level; we present results adjusted for municipality poverty level. Data analyses were conducted in 2014.

Results

Table 1 presents distributions of ERVs by week for October 1 through December 30 in 2011 and 2012. A total of 1,748 emergency room visits for PDD and 25,959 for SDD were reported for adult residents of Atlantic, Cape May, and Ocean counties to the NJDOH during the study period monitored in 2012. There were 53 emergency room visits for PDD and 527 for SDD during the week of the hurricane (October 29–November 4, 2012), representing a relative increase of 140.9% and 23.7%, respectively, when compared with the same week in 2011.

Characteristics of the study population are presented in Table 2. Results suggest minor changes in the age, sex, and municipality poverty distribution in ERVs between October 29–November 4, 2011, and October 29–November 4, 2012. Also in 2012, there was a decrease in the number of ERVs from Hispanic/Latinos and non-Hispanic Blacks and an increase in the number of ERVs by non-Hispanic Whites for both diabetes diagnoses. In Cape May County in 2012, most ERVs resulted from Hispanic/Latinos and Non-Hispanic Whites for PDD, and by non-Hispanic Whites for SDD.

Table 3 presents data on the number of municipalities by county with at least one case of a diabetes ERV during the week of October 29–November 4 by FEMA flood zones (i.e., with the municipalities completely within, completely outside, or partially within or overlapping flood zones). There was no clear pattern and no statistically significant difference, however, when comparing 2012 and 2011.

Spatial analysis revealed no consistent pattern for residents of the three targeted New Jersey counties (Figures 1 and 2 for Ocean County, as an illustrative example; Atlantic County and Cape May County figures are not presented—these other maps are available upon request from the authors). Briefly, in summary, data for Atlantic County showed a decrease for PDD in 2012, and a slight increase for SDD; Cape May County showed an increase for PDD and SDD, especially for the shore area. The Ocean County maps (Figures 1 and 2) were harder to analyze, due to the gap in territory near the shore, where water bodies are between the shore and mainland Ocean County. An increase was observed for PDD in 2012 compared with 2011 (Figure 1) not only for the shore area, but also for areas outside of flood zones, such as Plumsted Township and Jackson Township. An increase was also observed for SDD (Figure 2), mainly along the Ocean County shore area.

The distributed-lag Poisson generalized linear models analysis indicated an 84%

FIGURE **1**

Primary Diabetes Diagnosis by Municipality (*n* = 34), Ocean County, New Jersey, October 29–November 4

increase (1.84, *CI* = 1.12, 3.04, *p* = .01) in the rate of ERVs for PDD during the week of the hurricane in 2012 compared with the same week in 2011 (Model 1). In Model 2, ERVs in 2012 were 1.95 times higher than in 2011, after adjusting for age and sex (1.95, *CI* = 1.18, 3.21, *p* = .01). After further adjusting for race and ethnicity (Model 3) and municipal poverty (Model 4), the increase in PDD was no longer significant (data not shown). Results for SDD were not significant across the models (data not shown).

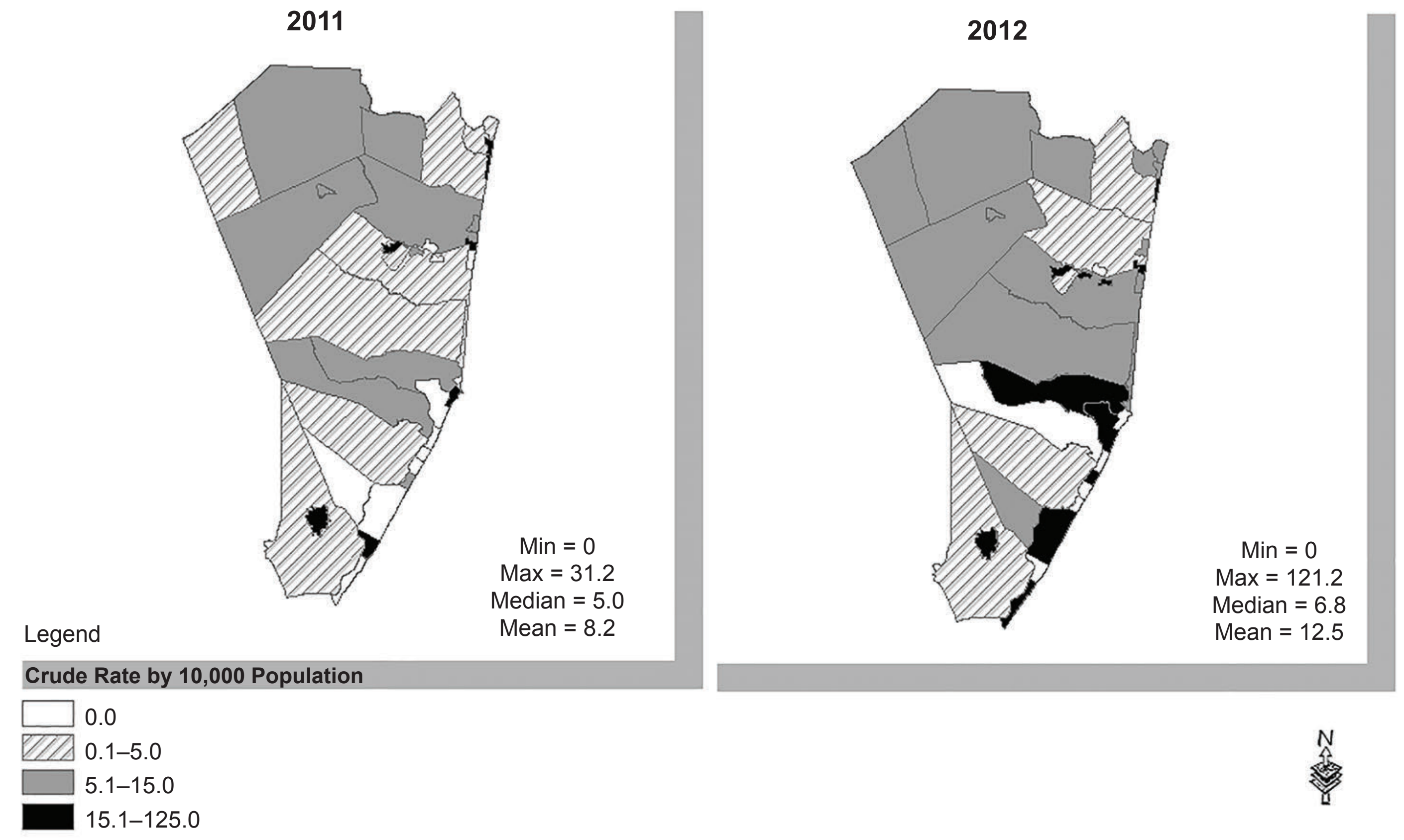
Discussion

The main results of the study showed an increase in PDD in three targeted counties in southern New Jersey from Hurricane Sandy during the week of this storm, compared with the previous year in the same time period. Results remained statistically significant when adjusted for age and sex. There were no statistically significant associations observed for SDD. In general, the geographic analysis of the three targeted counties suggested the areas designated as high flood areas had a higher number of ERVs during the week of the hurricane after accounting for population size.

This study suggested how a natural disaster such as a hurricane can affect individuals living with diabetes (i.e., as suggested by the substantial increase in the number of diabetes-related ERVs during the week of Hurricane Sandy, even if we cannot know the true reason for those ERVs). The observed increase was significant for a primary diagnosis of type II diabetes across three southern New Jersey counties studied. Results remained significant after adjusting for age and sex. Moreover, results suggest that the increased number of ERVs were made by non-Hispanic White individuals. This result is different from a previous study, which indicated African-Americans are more likely to visit emergency departments for diabetes care (Chin, Zhang, & Merrell, 1998). If non-Hispanic Whites had more resources to travel after the hurricane, however, this might explain the differences observed. For example, one possible explanation might be racial or ethnic minority populations could have been unable to get to the hospital if roads were closed or public transportation was not functioning or had limited function, as use of roads were suspended until they were cleared of damaged power lines, trees, etc. Although safety issues on roads likely affected entire communities, the extent to which safety issues disproportionately affected racial and ethnic minorities is unclear. On a global level, research has shown the devastating effects of natural disasters in populations already experiencing high levels of poverty (Silbert & Useche, 2012). Given how racial and ethnic

FIGURE **2**

Secondary Diabetes Diagnosis by Municipality (*n* = 34), Ocean County, New Jersey, October 29–November 4



minority groups are less likely to receive diabetes care and manage their health (Chin et al., 1998; McCall, Sauaia, Hamman, Reusch, & Barton, 2003; Mullins, Blatt, Gbarayor, Yang, & Baquet, 2005) and are more prone to have comorbidities (Anderson, Freedland, Clouse, & Lustman, 2001; Pan et al., 2012; Piette & Kerr, 2006), future research should explore the disproportionate burden of natural disasters in racially and ethnically diverse and poor communities.

Most studies to date exploring associations between natural disasters and health have reported a significant association between disasters and chronic disease outcomes (Chulada et al., 2012; Crook, Arrieta, & Foreman, 2010; Ford et al., 2006; Grimsley, Chulada, et al., 2012; Grimsley, Wildfire, et al., 2012; Neria & Shultz, 2012; Rath et al., 2011; Rhodes et al., 2010). Few studies, however, have analyzed diabetes-specific visits, multiple time periods, or the spatial patterning of diabetes-related ERVs. Prior research examining the effect of hurricanes on diabetes management found a significant increase in A1C levels in one out of three hospitals studied (Fonseca et al., 2009). Our study examined ERVs across numerous hospitals and areas most directly affected by Hurricane Sandy. We found significantly higher numbers of ERVs for PDD and SDD during the hurricane period in three counties of southern New Jersey that were most at risk of flooding and thus represent susceptible populations with vulnerable subpopulations during hurricanes. Additionally, other studies in the U.S. (Smith & Graffeo, 2005; Platz et al., 2007) have documented an increase of ERVs in general but only examined this within days after hurricanes made landfall. We extended previous findings by documenting changes in type II diabetes ERVs over several weeks before and after Hurricane Sandy and by comparing changes with the year prior to the hurricane to account for any possible demographic and seasonal trends.

The present study had potential limitations. First, data available only included patients visiting the emergency department who were not admitted for hospitalization. Severe outcomes related with diabetes management, including deaths, were, as a result, not taken into consideration in this study. Second, the study included numbers of visits as an outcome. If the same person went to the ER several times, that person was counted as different visits. This could introduce autocorrelation in the data resulting in potentially biased standard errors and possibly influenced tests of significance. The point estimates (rate ratio) obtained, however, would not have been affected and in the present study showed strong associations. Third, the rate ratios could be underestimated because only general acute care hospitals in New Jersey report ERVs to NJDOH; ERVs coming from specialized hospitals (e.g., Veteran Affairs hospital, skilled nursing facilities) or out-of-state hospitals were not included. Skilled nursing facilities, for example, might have had a large number of elderly people with diabetes management episodes related to Hurricane Sandy. Fourth, neighborhood poverty was measured at the municipality level. Census tracts (i.e., smaller geographic scale) would have been a more appropriate proxy for neighborhood contexts. Similarly, as patient addresses were not available for this study, ERVs were analyzed at the municipality level, which potentially concealed heterogeneity within each municipality. It should be noted that geocoding ERVs using patient addresses would have allowed for a more accurate categorization regarding FEMA flood zone areas. Finally, the data were derived from hospital billing information and so the municipality of residence associated with ERVs after the hurricane could be from a temporary home, potentially misleading the relationship with the flooding zone. Further research is needed to examine the significance of ERVs associated with flood zone areas defined by FEMA.

Strengths of our study include using outcomes based on standard clinical reporting criteria and not self-reported measures. This study targeted three southern counties of New Jersey that experienced detrimental impacts from Hurricane Sandy and have higher diabetes prevalence. Moreover, our study may be generalized to adult populations of those three counties in New Jersey because it included visits to the emergency room at every general acute care hospital.

Conclusion

In conclusion, we observed substantial increases in ERVs for primary type II diabetes diagnoses associated with Hurricane Sandy in New Jersey. Future public health preparedness efforts during storms should include planning for healthcare needs of populations living with diabetes. Specifically, results from our study suggested some targeted interventions hospitals, public health agencies, and community members can undertake to better manage diabetes during natural disasters. First, our findings, as well as recent research conducted by federal agencies (Lurie, Manolio, Patterson, Collins, & Frieden, 2013), suggest the need for hospitals to be prepared with enough medical and staff resources during the week of a natural disaster to care for populations with diabetes. Second, other nonhospital-based personnel such as police officers, firefighters, and volunteer medical and nursing students should be trained on emergency healthcare needs during and after natural disasters. Third, efforts to facilitate the availability of glucose monitoring devices, insulin, syringes, and antibiotics in community-based emergency shelters should also be considered. Finally, educational campaigns are needed to encourage those diagnosed with type II (and type I) diabetes to have adequate battery supplies for glucose monitoring devices during disasters; to prepare medication travel bags, because mandatory evacuations can happen suddenly; to use stress management techniques during and after natural disasters to alleviate anxiety potentially leading to poor glycemic control; and to keep an updated list of medications and doses taken in wallets or purses to be presented to any healthcare provider who may need to provide temporary medical care.

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