Received: 8 November 2021 | Revised: 20 January 2022 | Accepted: 24 January 2022

DOI: 10.1111/jgs.17702

Journal of the
American Geriatrics Society

Hospitalizations for chronic conditions following hurricanes among older adults: A self-controlled case series analysis

Sue Anne Bell PhD, FNP-BC, FAAN[1] | **John P. Donnelly MSPH, PhD**[2] | **Wang Li MSc**[1] | **Matthew A. Davis MPH, PhD**[1,2]

[1]University of Michigan School of Nursing, Ann Arbor, Michigan, USA

[2]University of Michigan School of Medicine, Ann Arbor, Michigan, USA

Correspondence
Sue Anne Bell, University of Michigan School of Nursing, 400 North Ingalls Building, Ann Arbor, MI 48109, USA.
Email: sabell@umich.edu

Funding information
Research reported in this publication was supported by National Institute on Aging of the National Institutes of Health under award number K23AG059890 (Bell, PI). The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health.

Abstract

Background/Purpose: Extreme events such as hurricanes adversely impact healthcare systems and the communities they serve. The degree to which hurricanes affect healthcare use among high need groups such as older adults with chronic conditions has not been well examined, nor has the impact of hurricane severity on health outcomes. We characterized hospitalizations among older adults by chronic condition after eight large-scale hurricanes in the United States.

Methods: Using a combination of administrative healthcare data and the Federal Emergency Management Agency's Disaster Declaration database we conducted a self-controlled case series analysis. We identified Medicare beneficiaries who were exposed to one of eight hurricanes and compared hospitalizations in the 30-days after a hurricane to hospitalizations in the rest of the calendar year of the hurricane. We examined hospitalizations (1) in total, (2) separately for diabetes, congestive heart failure (CHF) and chronic obstructive pulmonary disease (COPD) admissions, and (3) by hurricane damage category.

Results: Among all older adults exposed, hospitalizations in the 30-day period after each disaster increased for all three chronic conditions; diabetes (incidence rate ratio [IRR] = 1.06, 95% confidence interval [CI] 1.03, 1.10), COPD (IRR = 1.06, 95% CI 1.04, 1.08), and CHF (IRR = 1.19, 95% CI 1.17, 1.21. In the 30-to-60-day period hospitalizations also increased for each chronic condition; diabetes (IRR = 1.06, 95% CI 1.03, 1.10), COPD (IRR = 1.12, 95% CI 1.10, 1.15), and CHF (IRR = 1.32, 95% CI 1.30, 1.34). Substantial differences in hospitalizations were observed according to individual hurricane and by the chronic disease examined.

Conclusion: Exposure to hurricanes is associated with an increase in hospitalizations for chronic conditions across all hurricane damage categories. As disasters are expected to increase in strength and frequency, our results underscore the need for response strategies and health policy planning for healthcare systems designed to address the health needs of older Americans with chronic conditions.

 © 2022 The American Geriatrics Society.

KEYWORDS
disasters, hospitalizations, hurricanes, policy

INTRODUCTION

Disasters caused by extreme weather such as hurricanes have wreaked havoc across the United States in recent years, causing severe impacts to individuals and communities. These impacts are especially cause for concern among older adults, a population that is growing exponentially.[1] Although hurricanes may broadly contribute to increased healthcare utilization, they may have especially severe effects on individuals with chronic conditions. Chronic conditions in particular already affect this age group, where 80% of American older adults (defined in this study as 65 or older) have one or more chronic health condition.[2] Research evidence that defines the state of health for older adults after disasters is critically needed in order to build more effective disaster response plans than those that have characterized recent large-scale disasters but also to support healthy communities that can withstand the effects of the expected increase in catastrophic disasters.[3] Further, disasters affect communities differently, where examining wind speed or hurricane strength category may be of less importance than the amount of damage a community sustained, which will contribute to challenges in long-term recovery.

Equally pressing is an understanding of best practices for research around disaster-related morbidity and mortality.[4] Research methodologies in the study of disasters and health vary substantially, as do sources of data. There has not been a sustained investment in developing standardized sources of data related to disasters and health, or in conducting rigorous evaluation of research methodologies that connect health outcomes to disasters.[5] In the absence of data collected specifically for the purpose of measuring disaster morbidity, secondary sources of health information, connected via geographic identifiers, represent an alternative. More specifically, the use of administrative data connected to disaster events is an ideal, and underexplored source of information about health outcomes.[6] The overwhelming majority of older Americans have Medicare insurance, where analyses of Medicare data have been considered essential to informing healthcare, and to guide healthcare policy.[7] Connecting these data to disaster events represents a logical application to understanding resulting morbidity and mortality, however, there exist only a handful of studies that have done so.[8–12]

We conducted a self-controlled case series to address this gap and to determine the associations of hurricane events with hospitalizations for chronic conditions among older adults in the US. Specifically, we characterized admissions for chronic obstructive pulmonary disease (COPD), congestive heart failure (CHF), and diabetes among Medicare beneficiaries following several large-scale hurricanes in the United States.

Key points

- Hospitalizations for any cause, and those for diabetes, congestive heart failure, and chronic obstructive pulmonary disease, increased after the large-scale hurricanes examined and differed by damage category.
- Chronic conditions are a driver of hospitalizations for older adults after large-scale hurricanes, underscoring the need for response strategies and health policy planning designed to address the health needs of older Americans with chronic conditions.
- Rigorous evaluation of research methodologies that connect health outcomes to disasters is needed to better understand and support health in relation to the advancing impacts of climate change.

Why does this paper matter?

This manuscript describes increases in healthcare use after a disaster among older adults, and this matters because it advances the understanding how disasters affect the health of older adults contributes to the larger goal of building systems to support older adults to be ready for disaster events—particularly in terms of the healthcare resources they may need.

METHODS

We used Medicare administrative claims data from adults aged 65 or older who resided in a Zone Improvement Plan (ZIP) code affected by one of eight federally declared hurricane disasters between 2004 and 2012 to perform a self-controlled case series analysis. We determined the change in all-cause hospitalizations and hospitalizations for three chronic conditions (COPD, CHF, and diabetes)

in two exposure periods (0–30 days and 31–60 days) and compared these to admissions in the other 240 days before the hurricane. This study received ethical approval from the University of Michigan Health and Behavioral Sciences institutional review board (HUM00144124).

Data sources and study sample

The Medicare Provider and Analysis Review (MedPAR) file combined with the Master Beneficiary Summary File (MBSF) base was used as the primary data sources. MedPAR contains final action stay records for acute inpatient hospitalizations for individuals aged 65 or older and contains information for all fee-for-service Medicare beneficiaries using hospital inpatient services. Each MedPAR record represents one stay/one claim, and in this study, we examined only hospitalizations and excluded claims from Skilled Nursing Facilities.

We restricted our study population to older adults aged 65 or older who resided in counties with a Federal Emergency Management Agency (FEMA) disaster declaration,[13] requiring Individual Assistance (IA) support. IA provides support to families and individuals in counties with federal disaster declarations and is conceptualized in this study as a more specific measure of the severity of disaster exposure. We considered a study participant as exposed if their pre-disaster ZIP was in an affected county. Individuals who died prior to the date of the hurricane were excluded (n = 46,518).

The eight hurricanes under study are Frances (2004), Ivan (2004), Katrina (2005), Rita (2005), Wilma (2005), Ike (2008), Irene (2011), and Sandy (2012). These hurricanes were selected based on National Oceanic and Atmospheric Administration (NOAA) estimates of total cost and were among the most costly hurricane disasters occurring between 2004 and 2012.[14] The hurricanes were divided into damage categories based on NOAA cost estimates; using low, medium, and high (Table 1).

The MBSF base was merged with open-source FEMA disaster declarations data to generate the denominator file that includes beneficiaries in disaster-affected areas. MedPAR files were merged to the denominator file to identify the hospitalizations that defined the study cohorts for each of the eight hurricanes. Data was aggregated from years 2004 to 2012. We then used Centers for Medicare and Medicaid Service's Hierarchical Condition Categories (HCC) software[15] to determine hospitalizations for congestive heart failure, diabetes and chronic obstructive pulmonary disease within a defined period after a disaster. The primary ICD-9-CM diagnosis code was used to identify hospitalizations for each of the chronic disease outcomes. Data was structured for a self-controlled case series analysis to investigate the change in hospitalizations for chronic diseases post-disaster by chronic conditions and by all-cause admissions.

Hurricane exposure

We examined hospitalizations in the first 30 days after the hurricane, and in a second exposure period from 31 to 60 days after the disaster and compared to the period 240 days before the disaster.

Hospitalizations for chronic conditions

The endpoint was all-cause hospitalizations and hospitalizations for diabetes, COPD, and CHF within the exposure

TABLE 1 Hurricane disasters included in study

Hurricane	Month of landfall	Cost in billions[a]	Category at landfall	Landfall location
High damage				
Katrina	August 2005	$160.0	5	Orleans Parish, LA
Sandy	October 2012	$70.2	1	Atlantic County, NJ
Ike	September 2008	$34.8	2	Galveston County, TX
Medium damage				
Ivan	September 2004	$27.1	3	Baldwin County, AL
Wilma	October 2005	$24.3	2	Collier County, FL
Rita	September 2005	$23.7	3	Jefferson County, TX
Low damage				
Irene	August 2011	$15.0	1	Carteret County, NC
Frances	August 2004	$13.6	2	Martin County, FL

[a]Consumer price index adjusted to 2015.

Source: Billion-Dollar Weather and Climate Disasters https://www.ncdc.noaa.gov/billions/events/US/2000-2015

periods by damage categories. These three conditions were identified as conditions of interest as they were among the most common admission conditions using HCC software.

Statistical analysis

Using the Centers for Medicare and Medicaid Services Hierarchical Conditions Category (HCC) risk adjustment score, we determined the most frequent HCC admission categories among the total sample after the hurricanes. Of the top five, which included renal failure and cardiac arrhythmias, we investigated congestive heart failure, chronic obstructive pulmonary disorder, and diabetes based on clinical judgment, literature review, and our own past research.[16] HCCs are a risk adjustment tool that were developed to determine reimbursement for various Medicare plans as well as to align care resources with the clinical needs of a population,[15] and are used in this study as a metric of most common reasons for admission. To be included in the study, an individual must have had a hospitalization in one of the three periods of the study; exposure 1 (0–30 days), exposure 2 (31–60 days), or the control period.

We then performed a self-controlled case series analysis,[17,18] a case-crossover study variant where each person serves as their own control, such that temporally invariant confounders are controlled for by design. We used conditional fixed-effect Poisson regression to measure the within-person differences in the rate of an outcome following different exposures. This study design is ideal for situations in which limited granular data are available to assess potential confounders.

Our Poisson fixed effect model was constructed to estimate incidence rate ratios (IRRs) with 95% confidence intervals (CIs) measuring the change in hospitalization rate in the exposure period after each hurricane versus the other 240 days before the hurricane (the control period). IRRs were examined for each of the chronic conditions, by damage category, and by total. We examined one claim per hospitalization to avoid double counting hospitalizations. We used two-sided hypothesis testing and set statistical significance at P less than 0.05. All analyses were conducted with Stata software version 14.2 (StataCorp, College Station, TX).

RESULTS

We identified 1,713,300 fee for service beneficiaries that met the study criteria of residing in a disaster affected area during the study years, with 3,629,637 hospitalizations. Of this, 328,611 were hospitalized during the 0-to-30-day exposure period and 334,046 during the second exposure period of 31–60 days (see Figure 1). In the non-exposure period, there were 2,359,068 hospitalizations. The number of hospitalizations ranged from a low of 173,278 during Hurricane Ike to 662,315 during Hurricane Irene.

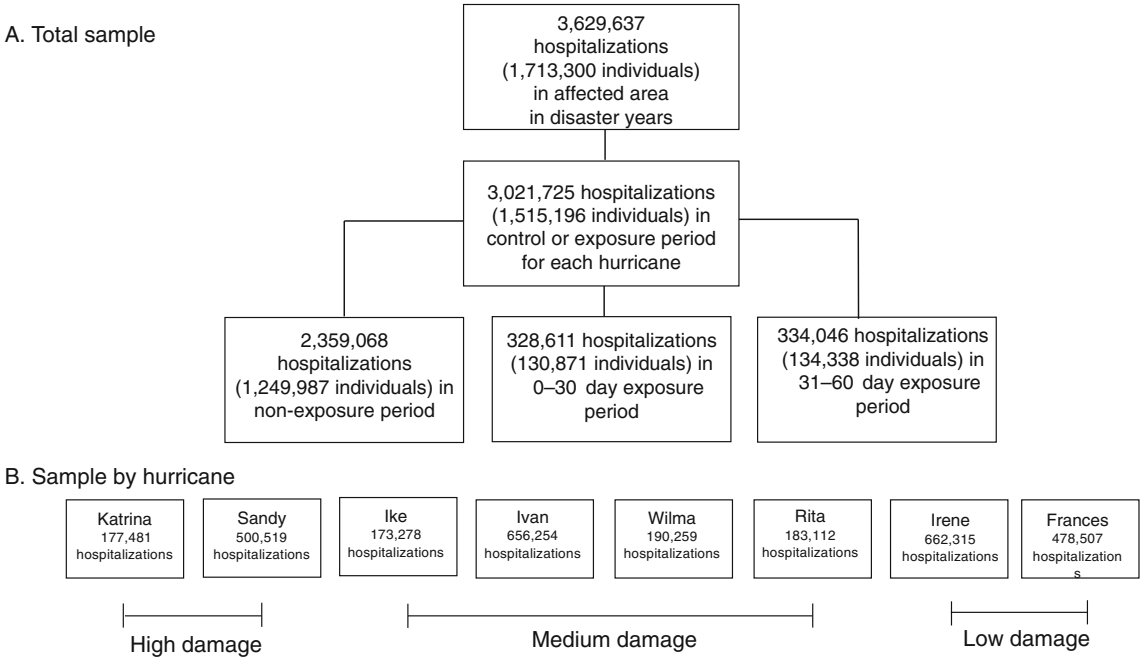

FIGURE 1 Sample selection diagram

TABLE 2 Effect of hurricane by hospitalization type and damage category

	Low damage(Frances and Irene)			Medium damage(Wilma, Rita, Ike, and Ivan)			High damage(Sandy and Katrina)		
	240 days before	**0–30 days post**	**31–60 days post**	**240 days before**	**0–30 days post**	**31–60 days post**	**240 days before**	**0–30 days post**	**31–60 days post**
All cause	$N = 704,300$			$N = 734,981$			$N = 414,448$		
Event rate (per 100 py)	191.4	204.7	224.1	193.6	211.6	220.0	194.2	220.1	206.6
IRR (95% CI)	Ref	1.08 (1.07–1.08)	1.19 (1.19–1.20)	Ref	1.10 (1.09–1.11)	1.16 (1.15–1.17)	Ref	1.14 (1.13–1.15)	1.09 (1.08–1.10)
Heart failure	$N = 46,484$			$N = 50,455$			$N = 27,642$		
Event rate (per 100 py)	150.8	169.7	192.7	151.0	177.2	199.2	148.2	190.1	193.6
IRR (95% CI)	Ref	1.13 (1.10–1.16)	1.30 (1.27–1.33)	Ref	1.18 (1.15–1.21)	1.34 (1.31–1.38)	Ref	1.29 (1.25–1.34)	1.33 (1.29–1.38)
COPD	$N = 27,415$			$N = 28,399$			$N = 16,407$		
Event rate (per 100 py)	148.5	142.9	162.0	148.0	157.1	158.9	144.5	174.3	174.9
IRR (95% CI)	Ref	0.97 (0.93–1.00)	1.10 (1.06–1.14)	Ref	1.07 (1.03–1.10)	1.09 (1.05–1.12)	Ref	1.21 (1.16–1.27)	1.23 (1.17–1.28)
Diabetes	$N = 12,270$			$N = 12,040$			$N = 8162$		
Event rate (per 100 py)	138.4	140.3	147.7	135.8	144.2	148.9	138.7	154.1	135.8
IRR (95% CI)	Ref	1.02 (0.96–1.08)	1.07 (1.02–1.13)	Ref	1.06 (1.01–1.12)	1.10 (1.05–1.17)	Ref	1.11 (1.05–1.19)	0.99 (0.92–1.06)

Notes: Event rates represent the total number of hospitalizations observed in a period divided by the total person-time of exposure for individuals with a designated hospitalization type. IRRs estimated from conditional, within person fixed effects models.

Abbreviations: COPD, chronic obstructive pulmonary disease; IRR, incidence rate ratio; py, person-years.

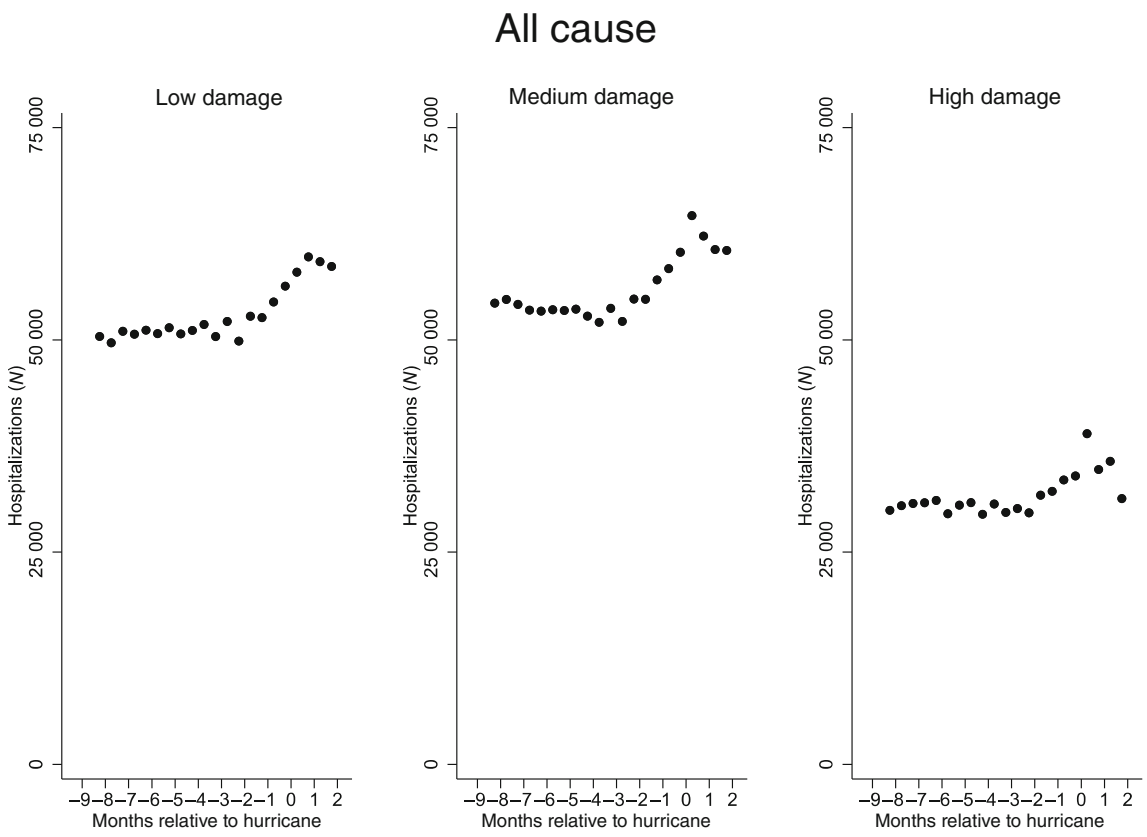

FIGURE 2 All-cause hospitalizations before and after hurricanes, by month

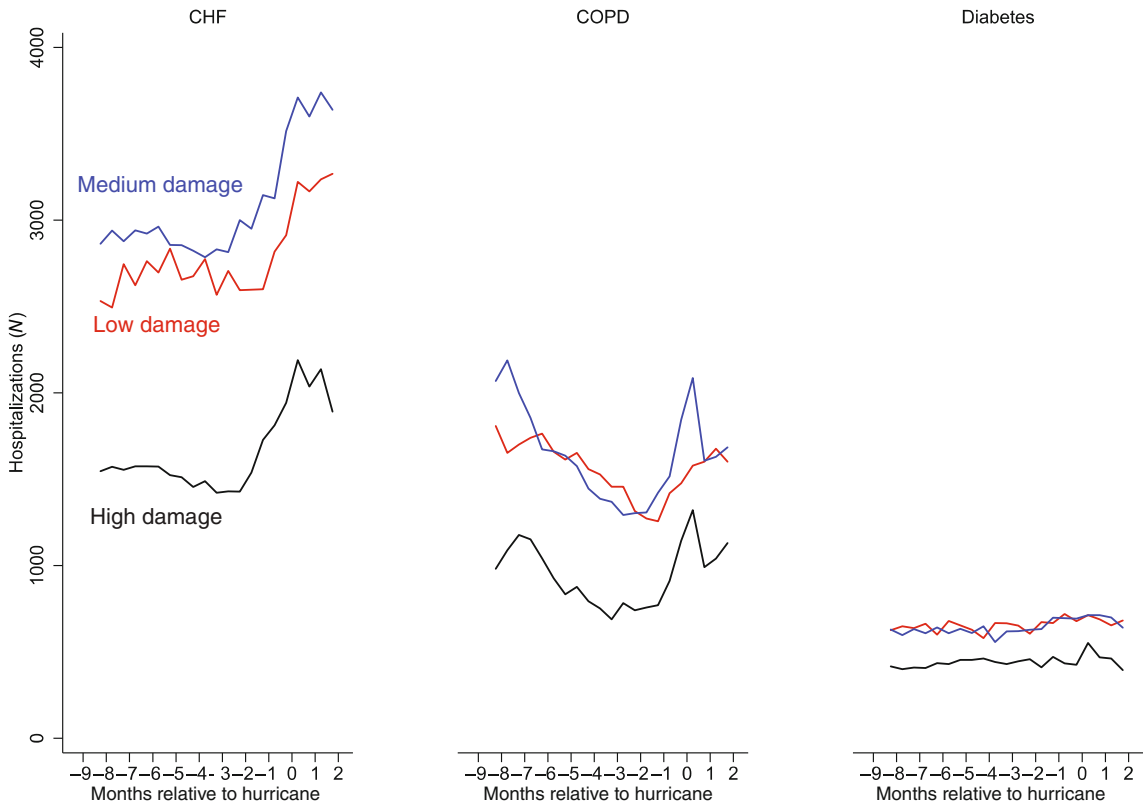

FIGURE 3 Hospitalizations for CHF, COPD, and diabetes, before and after hurricanes, by month

Across all disasters, the overall effect in the 0–30 day exposure period was a 10% increase in all-cause hospitalizations (IRR = 1.10, 95% CI 1.10, 1.11), and in the second exposure period of 31–60 days a 15% increase (IRR = 1.15, 95% CI 1.15, 1.16). Among all individuals in the sample, hospitalizations in the 30-day exposure period after each disaster increased across the three chronic conditions; diabetes (IRR = 1.06, 95% CI 1.03, 1.10), COPD (IRR = 1.06, 95% CI 1.04, 1.08), and CHF (IRR = 1.19, 95% CI 1.17, 1.21). In the 30-to-60-day period exposure, for all three chronic conditions; diabetes (IRR = 1.06, 95% CI 1.03, 1.10), COPD (IRR = 1.12, 95% CI 1.10, 1.15), and CHF (IRR = 1.32, 95% CI 1.30, 1.34).

Table 2 describes effects by damage category. In most of the outcomes examined, the 0-to-30-day period showed a higher rate of hospitalizations across damage category than in the 31-to-60-day exposure period. The exception for this was a decrease in all-cause hospitalizations and those for diabetes within the second exposure period after high damage hurricanes. See Figures 2 and 3.

DISCUSSION

After a disaster, the focus is often on immediate health emergencies, leaving less focus on exacerbations of chronic illness that may occur in a disrupted environment. This study demonstrates that chronic conditions are a driver of hospitalizations for older adults after large-scale hurricanes and further quantifies the relationship between chronic disease and large-scale hurricanes among older adults. These three chronic diseases are already among the most common in older adults, and our study supports the implication that factors related to a hurricane's impact on a community contribute to adverse health outcomes that can lead to hospitalization. These factors may include disrupted or limited access to health care, disruption in normal patterns of healthy living such as diet or transportation, challenges in obtaining medications or medical treatments,[19–23] each of which are a place for targeted interventions related to disaster readiness for older adults.

The effect sizes reported in this study varied by hurricane although an overall increase was observed when examining the total study population. The variation by damage category is not surprising given that while by their nature hurricanes differ in terms of strength and impact, other factors such as population size and geographic area affected and infrastructure and community supports of the locality affected are considerations. Further, while disaster declarations are an accepted definition of disaster exposure, but these may not match exactly with lived experience, or harms of a hurricane. A 2020 National Academy of Medicine report substantiates the dearth of research on disaster morbidity and calls for research to identify and test appropriate methods for developing population estimates of disaster related morbidity.[4] This attests to the limited understanding and focus on disaster-associated morbidity. Indeed, a recent systematic review of health outcomes for older adults after disaster found substantial variation in research methodology to measure disaster morbidity, and further, challenges in replicating existing studies.[16] Far more attention has been given to studying disaster mortality for which there is a stronger scientific understanding, but also for which outcomes and data may be more clearly defineable.[24–26] In this study, we rigorously evaluated the impact of disasters on chronic disease hospitalizations, thereby providing evidence to inform policy decisions, emergency planning, and interventions to support healthy aging throughout the disaster life cycle.

Despite this, there remains a lack of focus on access to healthcare for chronic disease care in emergencies, particularly around to mitigation actions to address chronic disease and disasters and innovative ways to support older adults living with chronic conditions to be ready for disaster events in their communities. Much of the responsibility for maintaining population health during disasters is at the local public health and emergency management level, rather than among hospitals. However, funding to support public health preparedness, including programs such as the U.S. Department of Health and Human Service's (DHHS) has been on the decline,[27] as has been support for disaster-related morbidity and mortality research,[4] an issue that has been highlighted by the current COVID-19 pandemic. With increased funding and research, advancements can be made to address chronic healthcare needs during and after emergencies. For example, current policy efforts exist which could be expanded upon to address the needs of such populations during disasters. One of these is the emPOWER program,[28] a collaborative effort between DHHS and CMS to identify beneficiaries who use electricity-dependent medical equipment. This study can inform expansion of the emPOWER program, to identify those most vulnerable with chronic disease prior to hurricanes thereby avoiding unnecessary hospitalizations after hurricanes and other disasters.

This study has several limitations. We limited our study to fee-for-service Medicare beneficiaries aged 65 years and older, which may affect the generalizability of the findings. For example, results may be different among older Americans who are enrolled in Medicare Advantage plans, in that individuals in these plans generally have better health outcomes. Additionally, since disaster declarations are at the county level, this does not

allow for measurement of the differential effects of the hurricanes within these counties, where community-wide damages may have differed greatly. The within persons design of the study prevents bias from potential confounders such as age, sex, income, education, or racial and ethnicity. It is possible that seasonality could at least partially explain the observed associations. To address this, we performed a sensitivity analysis (see Table S1) showing that hospital admissions do not begin to increase until immediately before a disaster declaration, which occurred at different times throughout the fall hurricane season. However, given our analysis of chronic conditions, we would not expect to see seasonal variation with admissions for diabetes and to a lesser extent, heart failure. While we view the within-person design as a strength of this study where participants serve as their own control, the knowledge that significant racial disparities and gaps exist during non-disaster times,[29] indicates these are likely exacerbated during a disaster, calling for specific interventions to support diverse communities.

Hospitalizations for any cause, and those for diabetes, congestive heart failure, and chronic obstructive pulmonary disease, increased in the months after the eight large scale hurricanes examined. Addressing chronic disease care for older adults needs to be included as a fundamental aspect of disaster response planning.

CONFLICT OF INTEREST

The authors have no conflicts.

AUTHOR CONTRIBUTIONS

Sue Anne Bell: study concept and design, data acquisition, preparation of manuscript. **John P. Donnelly**: analysis and interpretation of data, and preparation of manuscript, **Wang Li**: data analysis, **Matthew A. Davis**: study concept and design, interpretation of data.

SPONSOR'S ROLE

Research reported in this publication was supported by *National Institute on Aging* of the National Institutes of Health under award number K23AG059890 (Bell, PI). The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health.

ORCID

Sue Anne Bell

TWITTER

Sue Anne Bell @sueannebell

REFERENCES

1. Colby S, Ortman J. *Projections of the Size and Composition of the U.S. Population: 2014 to 2060*; 2015.
2. National Council on Aging (2021). The Top 10 Chronic Conditions in Adults 65+. https://www.ncoa.org/article/the-top-10-most-common-chronic-conditions-in-older-adults Accessed February 11, 2022.
3. Committee on Increasing National Resilience to Hazards and Disasters; Committee on Science E, and Public Policy; The National Academies. *Disaster Resilience: A National Imperative 2012*; 2012.
4. National Academies of Science EaM. *A Framework for Assessing Morbidity and Mortality After Large-Scale Disasters*; 2020. https://www.nap.edu/read/25863/chapter/1#ii Accessed February 11, 2022.
5. Birnbaum ML, Daily EK, O'Rourke AP, Loretti A. Research and evaluations of the health aspects of disasters, part I: an overview. *Prehosp Disaster Med*. 2015;30(5):512-522. doi:10.1017/s1049023x15005129
6. National Institute of Aging. *Advancing Behavioral and Social Research on the Elderly in* Disasters; 2009.
7. Mues KE, Liede A, Liu J, et al. Use of the Medicare database in epidemiologic and health services research: a valuable source of real-world evidence on the older and disabled populations in the US. *Clin Epidemiol*. 2017;9:267-277. doi:10.2147/clep.S105613
8. Quast T. Emergency department visits by and hospitalizations of senior diabetics in the three years following Hurricanes Katrina and Rita. *Econ Disasters Clim Change*. 2019;3(2):151-160. doi:10.1007/s41885-019-0039-8
9. Quast T, Andel R, Sadhu AR. Long-term effects of disasters on seniors with diabetes: evidence from Hurricanes Katrina and Rita. *Diabetes Care*. 2019;42(11):2090-2097. doi:10.2337/dc19-0567
10. Bell SA, Abir M, Choi H, Cooke C, Iwashyna TJ. All-cause hospital admissions among older adults after a natural disaster. *Ann Emerg Med*. 2017;71(6):746-754. doi:10.1016/j.annemergmed.2017.06.042
11. Rosenheim N, Grabich S, Horney JA. Disaster impacts on cost and utilization of Medicare. *BMC Health Serv Res*. 2018;18(1):89. doi:10.1186/s12913-018-2900-9
12. Horney J, Rosenheim N, Zhao H, Radcliff T. The impact of natural disasters on Medicare costs in U.S. gulf coast states. *Medicine (Baltimore)*. 2019;98(19):e15589. doi:10.1097/md.0000000000015589
13. Federal Emergency Management Agency. *Disaster Declarations*. Accessed January 31, 2019. https://www.fema.gov/disasters
14. National Centers for Environmental Information. *Billion-Dollar Weather and Climate Disasters*. National Oceanic and Atmospheric Administration. https://www.ncdc.noaa.gov/billions/ Accessed April 1, 2019. 2022.
15. Fortuna RJ, Clark JS, Johnson WE, et al. Association between physician risk assessment, hierarchical condition categories, and utilization of medical services. *Popul Health Manag*. 2020;24(2):249-254. doi:10.1089/pop.2019.0236.
16. Bell SA, Horowitz J, Iwashyna TJ. Health outcomes after disaster for older adults with chronic disease: a systematic review. *Gerontologist*. 2020;60(7):e535-e547. doi:10.1093/geront/gnz123
17. Petersen I. Self controlled case series methods: an alternative to standard epidemiological study designs. *BMJ*. 2016;354:i4515. doi:10.1136/bmj.i4515
18. Weldeselassie YG, Whitaker HJ, Farrington CP. Use of the self-controlled case-series method in vaccine safety studies: review and recommendations for best practice. *Epidemiol Infect*. 2011;139(12):1805-1817. doi:10.1017/s0950268811001531

19. Kelman J, Finne K, Bogdanov A, et al. Dialysis care and death following Hurricane Sandy. *Am J Kidney Dis*. 2015;65(1):109-115. doi:10.1053/j.ajkd.2014.07.005
20. Bell SA, Banerjee M, Griggs JJ, Iwashyna TJ, Davis MA. The effect of exposure to disaster on cancer survival. *J Gen Intern Med*. 2020;35(1):380-382.
21. Bell SA, Horowitz J, Iwashyna T. Home health service provision after Hurricane Harvey. *Disaster Med Public Health Prep*. 2019;20:1-7. doi:10.1017/dmp.2019.27
22. Bell SACH, Langa KM, Iwashyna TJ. Health risk behaviors after disaster exposure among older adults. *Prehosp Disaster Med*. 2019;34:95-97. doi:10.1017/S1049023X18001231
23. Raulji C, Velez MC, Prasad P, Rousseau C, Gardner RV. Impact of Hurricane Katrina on healthcare delivery for New Orleans patients, 2005–2014. *Pediatr Blood Cancer*. 2018;65(12):e27406. doi:10.1002/pbc.27406
24. Arnold C. Death, statistics and a disaster zone: the struggle to count the dead after Hurricane Maria. *Nature*. 2019;566(7742):22-25. doi:10.1038/d41586-019-00442-0
25. Cruz-Cano R, Mead EL. Causes of excess deaths in Puerto Rico after Hurricane Maria: a time-series estimation. *Am J Public Health*. 2019;109(7):1050-1052. doi:10.2105/ajph.2019.305015
26. Kishore N, Marqués D, Mahmud A, et al. Mortality in Puerto Rico after Hurricane Maria. *New Engl J Med*. 2018;379(2):162-170. doi:10.1056/NEJMsa1803972
27. Assistant Secretary for Preparedness and Response. *Hospital Preparedness Program*; 2017. Accessed May 24, 2020. https://www.phe.gov/Preparedness/planning/hpp/Documents/hpp-intro-508.pdf
28. U.S. Department of Health and Human Services HHS emPOWER Map 2.0. U.S. Department of Health and Human Services. https://empowermap.hhs.gov/ Accessed February 11, 2022.
29. Aggarwal R, Chiu N, Loccoh EC, Kazi DS, Yeh RW, Wadhera RK. Rural–urban disparities: diabetes, hypertension, heart disease, and stroke mortality among black and white adults, 1999–2018. *J Am Coll Cardiol*. 2021;77(11):1480-1481. doi:10.1016/j.jacc.2021.01.032

SUPPORTING INFORMATION

Additional supporting information may be found in the online version of the article at the publisher's website.

Table S1 Time period and hospitalization type, including the −31 to −1 days before hurricane.

How to cite this article: Bell SA, Donnelly JP, Li W, Davis MA. Hospitalizations for chronic conditions following hurricanes among older adults: A self-controlled case series analysis. *J Am Geriatr Soc*. 2022;70(6):1695-1703. doi:10.1111/jgs.17702