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Quantifying the Health Impacts of Disasters on Medicare Beneficiaries

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Abstract

The growing Medicare population remains disproportionately vulnerable to health effects from natural disasters. While case studies have characterized impacts of individual disasters, comparative data using common measurements over time and across locations are not available. County-level Medicare claims for beneficiaries in the 48 contiguous U.S. States for 2008-2012 were merged with Federal Emergency Management Agency data for each U.S. county from 2007-2012 to create a balanced panel dataset. To estimate average annual within-county change in the percent of Medicare beneficiaries with health conditions, exposure to a disaster declaration and a hazard factor variable were compared using fixed-effects regression models adjusted for Medicaid eligibility and beneficiary age, gender, and race. Using the disaster declaration exposure we found significant negative (diabetes, high cholesterol) changes for counties with declared disasters. Using the hazard exposure factor variable resulted in significant positive (heart attack, diabetes, arthritis) and negative (diabetes, high cholesterol) changes in disaster exposed counties. Associations between disaster exposure and health outcomes among Medicare beneficiaries are mixed and should be explored further. This can inform the development of innovative and timely pre-disaster interventions, as well as contribute to enhanced disaster resilience among beneficiaries and the Medicare system.

Keywords: Health care delivery; Health systems; Disaster planning; Disasters; Medical records; Medicare

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Introduction

As we look to the challenge of building a more resilient future we face a triple threat - an aging population who increasingly live in highly vulnerable coastal areas where the number and severity of large-scale natural disasters is increasing. Specifically, the growing U.S. adult population over age 65 remains disproportionately vulnerable to health hazards resulting from natural disasters and are more likely than younger people to experience morbidity, mortality, or other health impacts as the result of disasters [1-10]. For instance, 64% of the people who died in Hurricane Katrina were over age 65 [11]. Several characteristics make the elderly more susceptible to the effects of natural disasters, including greater hazard zone occupancy, living in less hazard-resistant structures, and lower rates of both emergency preparedness and disaster recovery responses [12]. The frail elderly (e.g., those with impaired physical mobility, diminished sensory awareness, or chronic health conditions) are at especially high risk for disaster related morbidity and mortality [1,2,13].

Specific chronic conditions more prevalent in the elderly, including cardiovascular disease, chronic obstructive pulmonary disease, diabetes, and renal insufficiency, are frequently exacerbated by the conditions caused by disasters. These diseases can be exacerbated by disaster effects, such as reduced medication adherence, interrupted access to resources, stress, injuries, and infections [2]. Older adults, many of whom have multiple chronic conditions and comorbidities, are particularly at risk as deficiencies in chronic care lead to worse disease control and outcomes [14]. For example, after Hurricane Charley made landfall in Florida in 2004, one-third of households with at least one adult over age 60 with a pre-existing medical condition reported that the hurricane exacerbated the medical condition, while 28% reported that the hurricane prevented older adults in the household from receiving routine care for a pre-existing condition [15].

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The health impacts of disasters can be cumulative or change throughout the life course, however; few longitudinal studies have been conducted on the physical impacts of natural disasters. For example, after the 2011 Christchurch, New Zealand earthquakes, in addition to increases in acute coronary syndrome on the day of the earthquake, increases in blood pressure for elderly outpatients with hypertension were documented over the following year [16].

Findings in the current research are largely based on disaster-specific case studies, conducted in small geographic areas with relatively small, homogeneous samples rather than at the national-level using standard variables comparable across disasters, time, and different geographic locations, which would increase study comparability [16]. Therefore, there is a need for a systematic national inventory of natural disaster impacts on the health of people age 65 or older. In the absence of such knowledge, the promise of being able to proactively anticipate and mitigate the effects of future disasters on health status and health systems use among the U.S. population over age 65 will likely remain limited [17-19]. Our goal in this analysis was to describe the association between disaster exposure and chronic disease in U.S. adults over age 65 using publically available exposure data and longitudinal methods.

Methods

Data sources

To quantify the health impacts of natural disasters on the elderly in the U.S., we used publically available, county-level data from the Centers for Medicare and Medicaid Services [20] Geographic Variation Public Use File (GVPUF), which contains 100% of Medicare claims for the 50 U.S. States and Washington D.C., aggregated to the county level for the years 2008-2012. The GVPUF file also includes demographic information on beneficiaries (e.g., age, gender, race and ethnicity), prevalence data for 19 chronic conditions, and utilization and cost data at the county level [21]. The 19 conditions include heart attack, atrial fibrillation, chronic kidney disease, chronic obstructive pulmonary disease, depression, diabetes, heart failure, ischemic heart disease, breast cancer, colorectal cancer, lung cancer, prostate cancer, asthma, hypertension, high cholesterol, arthritis, osteoporosis, Alzheimer's disease, and stroke. Each variable was characterized as a percentage of the sample population. The CMS GVPUF suppresses data for counties with any data field with fewer than 11 beneficiaries; therefore, our sample included 1,539 U.S. counties in the 48 contiguous U.S. (55%) with complete demographic data. The final sample included 5 years of longitudinal data for each U.S. County with all demographic data, for a total sample of 7,695.

County-level hazard exposure was defined using Federal Emergency Management Agency (FEMA) data related to major disaster declarations as well as information on dollar amounts distributed to counties for disaster response and recovery [22-24]. To account for differences in the scope and severity of different disasters over the study period, a hazard factor exposure variable was created by conducting a factor analysis in Stata 11 (College Station, TX) using four variables available from

FEMA including: 1) the total number of days with major disaster declared, 2) the available public assistance divided by estimated county population, 3) housing assistance dollars approved divided by populations in all designated counties for the related disaster, and 4) other needs assistance dollars approved divided by populations in all designated counties for the related disaster. For analysis the hazard exposure factor variable was divided into four categories using increments of the standard deviation. No hazard exposure was defined as counties with zero days of major disaster declaration and no public, housing, or individual assistance funds distributed (N=5,408). Some hazard exposure was defined as a hazard exposure factor value greater than the minimum and less than one standard deviation from the mean (N=1,661). High hazard exposure was defined as a hazard exposure factor value between one and two standard deviations from the mean (N=282). Extremely high exposure was defined as hazard exposure factor value greater than two standard deviations from the mean (N=344).

Data analysis

FEMA disaster data was merged with the CMS GVPUF using the state and county FIPS codes to create a balanced panel dataset from 2008-2012. Descriptive analyses were conducted to explore changes in exposures and outcomes over time and to describe the demographic characteristics of the sample. To control for time-invariant confounders, fixed-effects regression models were used to estimate the average annual within-county change in the percent of the 19 chronic-health conditions among Medicare beneficiaries, adjusted for dual eligibility for Medicaid, percent of population living in poverty, and beneficiary age, gender, and race. Two models were developed to assess potential differences in health outcomes for different types of hazard exposure as defined by the FEMA data: 1) disaster declaration (yes/no); and 2) the four-level hazard exposure factor variable (none, some, high, and extreme). Changes in conditions not expected to be associated with exposure (e.g., colorectal cancers, osteoporosis, and Alzheimer's disease) were used as comparisons to demonstrate model validity. Analyses were conducted in Stata 13 using the FE option. As these analyses use only publically available secondary data, this research was considered exempt from Institutional Review (IRB2015-0811M).

Results

The hazard exposure factor ranged from -0.33 in counties with no exposure to disaster to 20.33 in counties with the highest disaster exposure. On average, counties classified as having some hazard exposure had major disaster declarations lasting 9 days and received \$6.39 in public assistance, \$1.50 in housing assistance, and \$0.23 in individual assistance per capita. High hazard exposure counties had major disaster declarations for approximately 15 days and received \$23.22, \$9.48, and \$1.65 in per capita public, housing, and individual assistance, respectively. Counties with extremely high hazard exposures had the longest

period of mean disaster declarations (26 days) and received the highest per capita public assistance (\$50.87), housing assistance (\$14.21), and individual assistance (\$3.24).

In the descriptive analysis, there were no substantive differences in the population demographic characteristics of the study counties over the five year period. For the 1,539 U.S. counties in the sample, the average age was approximately 71 years, 55% of the sample was female, 8.25% was African-American, and 20.7% were eligible for both Medicare and Medicaid. However, county demographics did differ by hazard exposure level. Counties with extreme hazard exposure had populations with a larger percentage of Medicare beneficiaries, African-Americans, and people eligible for Medicaid and living in poverty (**Table 1**). Health outcomes also varied by hazard exposure level. Beneficiaries in counties with more hazard exposure consistently had more heart attacks, diabetes, heart failure, and arthritis (**Table 1**).

Results from the fixed-effects regression models were mixed. Counties with major disaster declarations had a significantly lower percentage of beneficiaries with diabetes and high cholesterol. Using the hazard factor variable, counties with extreme disaster exposure had a significantly higher percentage of beneficiaries with heart attacks, but fewer with diabetes and high cholesterol (**Table 2**).

Discussion

In our analysis of publically available county-level Medicare claims and FEMA disaster data, we found mixed associations between disaster exposure and chronic health outcomes among Medicare beneficiaries. Prior case-studies of single disasters have demonstrated associations between disaster exposure and increased prevalence of various health outcomes, including acute coronary syndrome, hypertension, diabetes, end-stage renal disease, chronic metabolic illness, psychiatric illnesses, and other chronic diseases [3-8]. Based on our findings, these differences may be due to the characteristics of the populations living in the

areas most vulnerable to disasters. These findings are consistent with an extensive literature on higher hazard zone occupancy by socially vulnerable populations [19,25,26].

While case studies of individual disasters can effectively characterize the impacts of a single type of disaster on health in a specific geographic location, collecting case-study data can be expensive and time consuming and in some cases may place additional burdens on individual respondents or health systems during their disaster response and recovery. More critically, because of its focus on a single event this type of case study research limits our capacity to enhance the resilience of the elderly, or the health systems that serve them, to future disasters of a different type, scale, or location.

Although inconsistent across health outcomes, our findings are still potentially useful for both individuals and health systems. These findings emphasize the need to focus on preparing for either increases or decreases in morbidities among the elderly in a post-disaster setting. Given limited resources, the ability to focus on the prevention and treatment of specific conditions most strongly associated with disaster exposure would potentially increase resilience of individual elderly and the health care system.

This research has several limitations. Because the CMS GVPUF file suppresses data for any field with fewer than 11 observations many rural counties were not included in the final study sample. As elderly residents of rural areas are likely to face unique concerns with regard to access to care during both the disaster and inter-disaster periods, this study may not represent those beneficiaries' experiences well. However, the suppressed counties include only 5% of the total U.S. population. In addition, the use of publically available county-level data can create potential exposure misclassification. Beneficiaries may have evacuated prior to the disaster or may have lived in a part of the county that was not impacted by the disaster. However, this potential for exposure misclassification is a problem in most

Table 1 One-Way Analysis of Variance (ANOVA) Regression Coefficients of Percentages for Demographic Variables and County-Level Health Outcomes by Hazard Exposure Level (N=7,695).

Not hazard exposure		Some hazard exposure	High hazard exposure	Extreme hazard exposure	Constant
Demographic variables					
Beneficiaries count	0	-396	16,479.69***	-4,335.83*	18,481.80***
Mean age	0	0.30***	0.83***	-0.26**	70.70***
Female	0	0.54***	1.19***	-0.29**	54.49***
African American	0	-1.35***	-0.79	8.23***	8.96***
Eligible for medicaid	0	0.22	-0.1	4.05***	20.90***
Population below poverty line	0	-0.71***	-1.45***	1.46***	16.61***
County-level health outcomes					
Heart attack	0	0.04***	0.09***	0.01	0.91***
Diabetes	0	-0.02	1.45***	2.03***	26.29***
Asthma	0	0.01	0.02	-0.07	4.35***
Heart failure	0	0.34***	1.72***	3.26***	14.86***
High cholesterol	0	0.03	1.11**	0.18	42.61***
Arthritis	0	0.88***	1.51***	2.36***	26.97***

Source: CMS GVPUF (2013)

Boldface indicates statistical significance (*p<0.05, **p<0.01, ***p<0.001) within each main effect

Table 2 Percent with each health outcome (95% Confidence Interval) by level of hazard exposure factor variable (N=7,695).

	Heart Attack	Diabetes	Asthma	Heart Failure	High Cholesterol	Arthritis
Average age	0.01 (0.00,0.02)	0.15*** (0.11,0.19)	-0.02 (-0.04,0.00)	0.21*** (0.16,0.25)	0.30*** (0.21,0.40)	0.20*** (0.13,0.27)
% Female	0.01 (0.00,0.02)	0.19*** (0.15,0.23)	0.02* (0.00,0.05)	0.06* (0.01,0.10)	0.24*** (0.15,0.33)	0.45*** (0.38,0.52)
% African American	0.00 (-0.01,0.01)	0.14*** (0.11,0.17)	0.02* (0.00,0.04)	0.11*** (0.08,0.15)	0.21*** (0.14,0.29)	0.08** (0.02,0.14)
% Medicaid eligible	0.00 (-0.01,0.01)	0.01 (-0.00,0.02)	0.04*** (0.04,0.05)	0.08*** (0.06,0.09)	-0.17*** (-0.20,-0.14)	0.00 (-0.02,0.03)
% below poverty line	0.00* (-0.01,0.01)	0.00 (-0.01,0.01)	0.00 (-0.01,0.01)	0.02*** (0.01,0.03)	-0.00 (-0.02,0.02)	-0.01 (-0.03,0.01)
2008	0.00 (0.00,0.00)	0.00 (0.00,0.00)	0.00 (0.00,0.00)	0.00 (0.00,0.00)	0.00 (0.00,0.00)	0.00 (0.00,0.00)
2009	-0.04*** (-0.05,-0.03)	0.56*** (0.52,0.60)	0.12*** (0.10,0.14)	-0.35*** (-0.39,-0.30)	1.56*** (1.47,1.64)	0.84*** (0.77,0.91)
2010	-0.03*** (-0.04,-0.02)	0.97*** (0.93,1.02)	0.19*** (0.17,0.22)	-0.65*** (-0.69,-0.60)	2.64*** (2.55,2.74)	1.47*** (1.39,1.54)
2011	-0.05*** (-0.07,-0.04)	1.32*** (1.27,1.37)	0.38*** (0.36,0.41)	-0.99*** (-1.05,-0.93)	3.82*** (3.71,3.93)	2.21*** (2.12,2.30)
2012	-0.06*** (-0.08,-0.05)	1.43*** (1.38,1.49)	0.47*** (0.44,0.50)	-1.43*** (-1.49,-1.37)	4.06*** (3.95,4.18)	2.85*** (2.76,2.95)
Hazard exposure						
Some	0.01 (-0.00,0.02)	-0.10*** (-0.13,-0.06)	0.00 (-0.02,0.02)	-0.03 (-0.07,0.01)	-0.15*** (-0.22,-0.07)	-0.02 (-0.08,0.04)
High	0.01 (-0.01,0.03)	0.16*** (0.08,0.23)	0.01 (-0.03,0.05)	0.07 (-0.02,0.15)	0.00 (-0.16,0.16)	0.14* (0.01,0.27)
Extreme	-0.00 (-0.02,0.02)	-0.10** (-0.17,-0.03)	-0.01 (-0.04,0.03)	-0.07 (-0.15,0.00)	-0.43*** (-0.58,-0.28)	-0.13* (-0.25,-0.01)
Some in previous year	0.01 (-0.00,0.01)	-0.06** (-0.09,-0.02)	-0.01 (-0.03,0.01)	0.01 (-0.03,0.04)	0.00 (-0.07,0.07)	-0.04 (-0.10,0.02)
High in previous year	-0.01 (-0.03,0.01)	0.11** (0.04,0.18)	-0.00 (-0.04,0.03)	0.06 (-0.02,0.14)	0.14 (-0.01,0.29)	0.05 (-0.07,0.17)
Extreme in previous year	0.02* (0.00,0.04)	-0.10** (-0.18,-0.03)	-0.02 (-0.06,0.02)	0.00 (-0.08,0.09)	-0.17* (-0.33,-0.01)	-0.10 (-0.23,0.03)
Constant	0.09 (-0.81,0.98)	2.95 (-0.55,6.45)	3.27*** (1.36,5.17)	-4.78* (-8.65,-0.91)	7.41 (-0.10,14.93)	-13.12*** (19.17,-7.07)
R ²	0.036	0.515	0.362	0.482	0.656	0.532

Source: CMS GVPUF (2013) and FEMA (2014)

Boldface indicates statistical significance (*p<0.05, **p<0.01, ***p<0.001)

disaster research, since FEMA disaster declarations are issued at the county level, which is not likely to be the best spatial level at which to characterize exposures [27]. This type of analysis may also have resulted in an underestimation of effects since beneficiaries who die are removed from the dataset, particularly if those exposed to disaster have higher death rates than those who were not exposed [28]. This is a preliminary study using publicly available data. The research team has requested and received permission from the National Center for Health Statistics (NCHS) to access restricted use individual-level Medicare claims data. The NCHS-CMS Medicare linked data file contains Medicare claims data from 1999 to 2007 for all individuals that participated in the National Health Interview Survey (NHIS) between 1997 and 2005. A follow-up study is planned.

Conclusions

Although inconsistent across health outcomes and exposure

measures, our findings are useful in emphasizing the need to focus on preparing the most socially and environmentally vulnerable Medicare beneficiaries for the potential health impacts of a disaster. It is clear that the most socially vulnerable beneficiaries (African-Americans, dual eligibles for Medicaid, and those living in poverty) are exposed to the highest hazard levels. Given limited resources, the ability to focus on the prevention and treatment of specific populations and conditions most strongly associated with disaster exposure could increase resilience of individuals and health systems. Further research is also needed to improve the specificity of the measurement of disaster exposure.

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