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Disparate Health Implications Stemming From the Propensity of Elderly and Medically Fragile Populations to Shelter in Place During Severe Storm Events

Joshua G. Behr, PhD; Rafael Diaz, PhD

Chronic conditions, disability limitations (mobility, cognitive, and sensory), and the need for assistance with activities of daily living are characteristics of elderly and medically fragile populations. Theory suggests that households with these vulnerability attributes are more likely to suffer storm-induced adverse and prolonged health consequences and, therefore, ought to evidence an increased propensity to evacuate prior to a severe storm event. Yet despite being more sensitive to storm disruption, the elderly and medically fragile populations are only slightly more likely to evacuate in the face of impending storms. This suggests, for these groups, there may be other factors such as income, transportation, and social and familial networks that may be attenuating the propensity to evacuate. The public health significance is found in that the propensity to shelter in place, rather than evacuate, may contribute to disparate health outcomes. Data illustrating the prevalence of these conditions and the propensity to shelter in place are derived from a sampling of Hampton Roads households following the 2011 Hurricane Irene.

KEY WORDS: access, ADL, chronic conditions, cognitive impairment, diabetes, disaster, disparate health, durable medical equipment, elderly, emergency preparedness, evacuation, frail, heart disease, hurricane, IADL, medically fragile, mobility impairment, pain management, sensory impairment, severe storm, shelter, vulnerability

This article presents a descriptive overview of several vulnerabilities related to chronic disease as well as mobility, cognitive and sensory impairments encountered by elderly populations residing in the Hampton Roads region when faced with an impending severe storm event. Theory suggests that the presence of family members within a household with these conditions may contribute to reduced preparation for an impending severe storm, limit response during the event itself, and constrain household adaptability and recovery after the event. Those households least able to absorb, manage, and adapt to the disruption to normal routines associated with severe storm events ought to place a high priority on event mitigation in the form of evacuation. Thus, the theoretical expectation is that vulnerable households (in terms of medical fragility and elderly) will evidence greater propensity to evacuate than nonvulnerable households. However, contrary to theoretical expectations, we find that there is a propensity of elderly populations to shelter in place. The public health significance is found in that the propensity to shelter in place, rather than evacuate, especially among populations that are peculiarly sensitive to disruptions in support systems and medical regimens, may result in disparate health outcomes. To illustrate the public health implications, we offer descriptive statistics that make clear the differences in several sentinel indicators of vulnerability between households that have only

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adult members (18 through 64 years of age, N = 2376 households) and more senior households (members 65+ years of age, N = 1437 households) as well as descriptive statistics illustrating differences in the propensity to evacuate among these groupings.

In August, 2011, Hurricane Irene originated off the coast of Africa as thunderstorms and formed storm status near Martinique where she then traveled through the Caribbean, first making landfall and achieving hurricane status over Puerto Rico, continued on to make US landfall as a strong tropical storm in the Outer Banks of northern North Carolina, crossed over the neighboring Hampton Roads region, and trekked the Atlantic Coast through New Jersey and New York. As the storm developed in the Atlantic and headed for the United States, both the news and emergency officials warned of the impending severity of the storm. The event brought more than 20 inches of rainfall to several Hampton Roads localities, resulted in extensive property damage and flooding within the mid-Atlantic and New England regions, and is one of the 10 top costliest disasters in the US history.

These original data are drawn from Hampton Roads households taken following Hurricane Irene. The Hampton Roads region includes more than 1.8 million citizens residing across 24 localities extending from Northeast North Carolina northward to the national capital region. Within months of Hurricane Irene, beginning in January, 2012, the authors conducted a random stratified telephone sampling of Hampton Roads households (of which 3813 households are drawn upon here) to identify where residents sheltered during the storm event as well as to gather information relating to medical-related vulnerabilities of these households.

● Vulnerability

The impact of severe storm events, such as Hurricane Sandy, Katrina, and Andrew, on coastal populations has been widely reported. During, and in the immediate aftermath of natural disasters, such as hurricanes, the elderly and medically fragile are more likely to suffer than other population groups.¹⁻⁵ Economic constraints, chronic medical conditions, mobility issues, and cognitive impairments are more prevalent in elderly populations.⁶⁻⁹ The elderly and medically fragile populations often exhibit reduced health status and heightened dependence that may limit the ability to prepare for and respond to severe storm events¹⁰⁻¹² and this, in turn, may contribute to longer-term adverse health outcomes.^{13,14}

Elderly populations, in particular, may be more vulnerable to the severe storm events. Fernandez et al⁷ assert that the vulnerability of the elderly

to catastrophic events may be enhanced because of impaired physical mobility, diminished sensory awareness, chronic health conditions, and social and economic constraints. Barney and Roush¹⁴ find that elderly people are especially fragile in that, as a group, they have heightened mobility impairments, hypertension, and arthritis. Rosenkoetter et al¹⁵ also note that limited transportation and living alone contribute to vulnerability. In addition, McGuire et al¹⁶ find that older adults are more likely to have a disability, be in need of special medical equipment, to require assistance when evacuating, and require a shelter that can accommodate medical equipment.¹⁷ In similar vein, Staley et al¹⁸ find that socially isolated elderly people with medical and/or mobility impairments are less likely to engage in preparedness and mitigation activities, thus further enhancing vulnerability.

● Sheltering in Place

Because the elderly suffer disproportionately from the impact and aftermath of severe weather events, a better understanding of the context in which elderly people and medically fragile populations choose to shelter in place, rather than evacuate, can inform interventions intended to lessen the suffering and adverse health outcomes stemming from such events. Most Hurricane Katrina mortalities, for example, were elderly citizens and, in most cases, these deaths occurred while sheltering in homes.^{19,20} Specifically, McCann²¹ reports that of 1330 people known to have died from Hurricane Katrina, 71% of those in Louisiana were older than 60 years and, according to Gullette,²² 47% were older than 75 years.

The elderly also may shelter in congregate care facilities, such as nursing homes and assisted living facilities. These populations may be vulnerable due to delay in making the decision to evacuate: "evacuation may be delayed because of a lack of resources or staff [or an] unavailability of beds at a comparable facility."²³ Hurricane Katrina, again, witnessed nearly 70 deaths in nursing homes.²¹ Within these facilities, understaffing, poor management, and lack of planning contributed to failed evacuation efforts.^{13,14,20}

Although Irene passed directly through Hampton Roads and was projected to be a severe storm event with the potential for catastrophic flooding, especially along low-lying coastal areas, which encompass much of Hampton Roads, the sizable majority of citizens sheltered in place. Sampling of households after the event documents a statistically significant difference in propensity to evacuate with 6.1% of households comprising solely adults aged 18 through 64 years exiting the region prior to the storm event contrasted with 8.3%

of households comprising solely seniors older than 65 years departing the region ($cv = 6.320$, $sig = .012$). A higher percentage of households with senior residents, relative to households with adult residents, heeded the warning to leave, yet sizable portions of both types of households sheltered in place.

● Medical Fragility

The concept of fragility addresses those who have conditions or impairments that interfere or limit what would be otherwise the normal activities of daily living (ADL). A generally accepted measure of disability that captures the functions that one must be able to adequately perform to live independently is the instrumental ADL, which includes activities such as the ability to use a phone, shopping, food preparation, managing finances, or following medication regimen.²⁴⁻²⁶ The inability to adequately perform these activities suggests diminished independence and a reliance on others to assist where one is experiencing a deficit, whether skilled nursing assistance, home health care services, or family and neighbors. These deficits may stem from normal age-related functional decline (eg, diminished motor skill and strength, failing eyesight) as well as disease or chronic condition. This functional decline makes it more difficult to respond and adapt to a stressor such as the rapidly changing environment. Thus, frailty is “multidimensional,”²⁷ “remains more a constellation of many conditions rather than a discrete clinical entity,”²⁸ is a “nonspecific state of vulnerability,”²⁹ and may describe a combination of aging and disease.^{30,31}

Table 1 presents percentage of households that have at least a single adult who is dependent upon others to help with normal daily activities such as bathing, getting dressed, feeding, or following medication schedules. Table 1 illustrates, by sheltering decision, the differences between households comprising solely adults aged 18 through 64 years and those comprising solely seniors older than 65 years. For those households comprising solely adults aged 18 to 64 years who also sheltered in place—meaning family members remained in primary residence during the storm—just more than 9% have at least 1 member of the household who is dependent upon others for ADL. In comparison, more than 13% of households composed entirely of seniors older than 65 years who also sheltered in place report at least 1 member who is ADL dependent. For those adult and senior households who evacuated the region, the percentages that have a member who is disability dependent are 9.7 and 15.3, respectively. These figures demonstrate, expectedly, that senior households, relative to adult households, exhibit a higher

probability of having a member who is ADL dependent. But, more importantly, the figures also reveal a remarkable feature of senior households: senior households with a member who is ADA dependent exhibit only a slightly greater propensity to evacuate the region relative to the propensity to shelter in place (ie, 15.3% vs 13.3%). According to theory, households with ADL dependence are more vulnerable and, *ceteris paribus*, should exhibit a heightened predisposition to evacuate. This modest difference of approximately 2% suggests that all else is not equal; that is, there may be other factors that constrain or frustrate the propensity of senior households with ADL dependence to evacuate.

● Chronic Conditions

The concept of medical fragility, more specifically, centers on the management of disease or chronic conditions. Often management of these conditions is through the supervision by medical professionals and prescription medication. For example, treatment of diabetes, hypertension, chronic obstructive pulmonary disease, arthritis, and cancer require good nutrition, medications, and regular access to professional medical care or an outpatient treatment venue (eg, dialysis). While the medical support arrangement customized for the patient may not be able to return the person fully to independence, the support system that surrounds the person ought to be calibrated to optimize the person’s self-determination and engagement in normal daily activities. Access to the support system, medical records, medical regimens, and nutrition that define this dependence on others may be easily upset or disrupted with the occurrence of a severe storm event, thus placing the person at higher risk for adverse health outcomes or a perturbation in health. The individual is a self-regulating entity that responds to stressors. Fragile populations have less flexible normal lines of defense and in a poststorm environment the interventions may not be available to counteract the noxious effect of the stressor.³² Medically fragile persons, by definition, have a limited reserve capacity to cope with the disruption which, in turn, may evolve a managed, tertiary condition into an acute condition.

The ability to weather the event and cope with the aftermath is challenging for those with chronic illnesses. About 80% of older adults have at least 1 chronic condition that makes them more vulnerable during a disaster relative to healthy people,³³ and those with a disability are more likely to have multiple chronic morbidities. The disruption in social support networks, which may be important in the management of a chronic condition within populations with cognitive and mobility issues, may have longer-term impacts on the health of

TABLE 1 ● ADL Dependence and Propensity to Evacuate by Household Composition

		HH Composition		
		HH Solely With Adults 18-64	HH Solely With Seniors 65+	
Activities of daily living (ADL)	Sheltered in place	No ADL dependent	90.8% (2013)	86.7% (1137)
	cv = 13.958, sig = .000	ADL dependent ^a	9.2% (205)	13.3% (174)
	Evacuated	No ADL dependent	90.3% (130)	84.7% (100)
	cv = 1.851, sig = .174	ADL dependent ^a	9.7% (14)	15.3% (18)

Abbreviations: CV, critical value; HH, household; sig, significance.
^acv = 1.256, sig = .253.

these populations.³⁴ The ability to manage a chronic condition and its associated medical regimen may be complicated by disruption to medication and care schedules, thus leading to negative health outcomes.³⁵ In the partial or total absence of safety-net providers, an increase in emergency department visits has been observed.³⁶ Overtaxed ambulatory systems operating at maximum or reduced capacity may be responsible for perpetuating health disparities for at-risk populations seeking care after a disaster.³⁷ Following Katrina, within treatment and refuge centers, “chronic illness was the overwhelming source of immediate demands... people with diagnosed hypertension, heart disease, diabetes, and asthma presented with worsened conditions due to lack of care after the storm, seeking acute care, ongoing care, and refills of lost prescription medications.”³⁸

Table 2 presents the percentage of households that report at least 1 member being treated for heart disease, hypertension, or high blood pressure as well as the percentage reporting at least 1 member being diabetic. The theoretical argument is made that households, especially senior households, exhibiting chronic conditions are more vulnerable to adverse health outcomes

stemming from the disruptive nature of severe storm events. Among senior households who sheltered in place, nearly 69% had at least a single member with heart disease relative to 47% of adult households. This indicates that senior households are more likely to have heart disease and, by extension, they ought to be vulnerable to severe storm disruptions. However, a further comparison between senior evacuated and senior sheltered-in-place households demonstrates that evacuated households are no more likely to include a member with heart disease relative to shelter-in-place households (67.2% vs 68.7%). This suggests that heart disease, viewed as an indicator of vulnerability, does not increase the predisposition of the household to evacuate. In similar fashion, more senior shelter-in-place households (31.4%), relative to adult households (21.7%), have at least 1 member with diabetes. Note again that senior evacuated households, relative to senior shelter-in-place households, are no more likely to include a member with diabetes (31.4% vs 25.2%). These figures appear, at simple face value, to demonstrate that chronic conditions such as heart disease and diabetes do not associate with a strong propensity to evacuate, yet it has been theorized that such chronic

TABLE 2 ● Chronic Conditions and Propensity to Evacuate by Household Composition

		HH Composition		
		HH Solely With Adults 18-64	HH Solely With Seniors 65+	
Heart disease	Sheltered in place	No heart disease	53.0% (1175)	31.3% (410)
	cv = 155.56, sig = .000	Heart disease ^a	47.0% (1043)	68.7% (898)
	Evacuated	No heart disease	56.9% (82)	32.8% (39)
	cv = 15.325, sig = .000	Heart disease ^a	43.1% (62)	67.2% (80)
Diabetes	Sheltered in place	No diabetes	78.3% (1739)	68.6% (899)
	cv = 40.923, sig = .000	Diabetes ^b	21.7% (483)	31.4% (412)
	Evacuated	No diabetes	79.9% (115)	74.8% (89)
	cv = .963, sig = .326	Diabetes ^b	20.1% (29)	25.2% (30)

Abbreviations: CV, critical value; HH, household; sig, significance.
^acv = 5.35, sig = .021.
^bcv = .553, sig = .598.

conditions may be more difficult to manage through a catastrophic event and, thus, signify vulnerability.

● Disruptions to Access

The medically fragile and elderly populations are especially sensitive to disruptions in the delivery of medical services stemming from a severe storm event.^{39,40} Persons with mobility disabilities and those who need help of others are, in general, more likely to encounter access barriers to health services.⁴¹ This access to health services is exacerbated in the presence of a catastrophic event. Often, elderly and medically fragile populations require transport assistance to and from appointments. Both the social and professional networks that facilitate transportation may be disrupted, resulting in delayed or missed appointments.¹³ In addition, primary care providers and community health service venues, many of which may already have been operating at or near capacity, may suffer structural damage and staffing shortages following a severe storm event, thus generating a backlog of demand that may take weeks or months to process.

Many patient records within hospital records departments, primary care offices, and clinics may be destroyed or limited by flooding. Residents who require access to medical history may have no way of making contact with closed offices. As related from Katrina, medical communities aiding residents were, “strained to do the right thing, but with mostly unhelpful or inaccurate oral histories from patients” it was difficult to get a true picture of medical needs.⁴² Missed or delayed access to primary care may impact the treatment of chronic conditions and the management of a medical regimen. The management of poststorm chronic condition becomes difficult as knowledge about, as well as access to, medications may become problematic. In addition, medical equipment may be damaged, misplaced, or nonfunctional due to power loss. Chronic illnesses that are otherwise easily managed can become life threatening when access to appropriate medicine and management is severed or delayed.²²

Table 3 shows the percentage of households who report at least 1 member who has ongoing appointments with a pain management doctor. Ongoing pain management is an indicator of medical fragility and viewed as a medical regimen that may be compromised by a disruptive severe storm event. Thus, those with ongoing pain management appointments are characterized as vulnerable. The percentage of shelter-in-place households that have at least 1 member with ongoing pain management is the same for adult and senior households (12.1% and 12.0%, respectively). The expectation is that households, especially senior households, with

such vulnerabilities ought to experience heightened propensity to evacuate. Although the evacuated senior households are more likely to have a member with ongoing pain management (16.2% and 12.0%, respectively), the statistical difference is not significant.

It is acknowledged that many residents may be dependent on durable medical equipment within the home as part of the management of chronic disease. It is further suggested that a household with medical equipment that would be disrupted with loss of electricity for several days is vulnerable. Table 4 shows that 10.7% of adult and 11.4% of senior households who sheltered in place have electric-dependent medical equipment. Evacuated senior households are more likely to have such medical equipment relative to shelter-in-place senior households (11.4% vs 14.3%), although this difference is only weakly significant. While this indicates that evacuated households are more likely to have electric-dependent equipment, the difference is modest at best. Again, although theory suggests vulnerability, these durable medical equipment households tend to shelter in place at rates similar with other households.

● Cognitive and Mobility Limitations

In general, older population groups have heightened prevalence of cognitive disorders and mobility limitations relative to younger population groups. Memory is associated with basic physical mobility in the independent elderly.⁴³ Cognitive limitations may condition risk perception of the severity of the impending event and self-efficacy in managing the disruptive nature of the event. Cloyd and Dyer⁴⁴ contend that these maladies may predispose the elderly people to shelter in place, rather than depart the region, and hinder their ability to cope with the aftermath of the catastrophic event. Langan and Christopher¹⁹ suggest that a major driver for sheltering in place was a perceived lack of confidence in information provided by the media and officials.¹⁵ Although mobility issues may make evacuation travel difficult or uncomfortable, departure from the region will often entail engaging in logistical efforts to coordinate transportation and making arrangements for an exit destination; communication barriers may make these tasks difficult.⁴⁵ The perception may be that it is difficult to replicate outside the region a network of support that an individual arranges to manage a disability or chronic condition. Without knowledge, preparation, or a plan to replicate the support system, the risk of exiting is seen as greater relative to remaining in the region.

As a condition of the aging process, we expect to see a larger share of senior households, relative to adult households, exhibiting mobility, sensory, and

TABLE 3 ● Pain Management and Propensity to Evacuate by Household Composition

			HH Composition	
			HH Solely With Adults 18-64	HH Solely With Seniors 65+
Ongoing appointments with pain management doctor	Sheltered in place cv = .004, sig = .949	No PM appointment	87.9% (1944)	88.0% (1154)
		PM appointment ^a	12.1% (268)	12.0% (158)
	Evacuated cv = .481, sig = .488	No PM appointment	86.8% (125)	83.8% (98)
		PM appointment ^a	13.2% (19)	16.2% (19)

Abbreviations: CV, critical value; HH, household; sig, significance.

^acv = 1.361, sig = .231.

cognitive limitations. Table 5 shows that 16.8% of senior households who sheltered in place have at least 1 member who cannot walk, has difficulty walking, or uses a wheelchair while 8.6% of adult households have a member with such a limitation. Senior households with mobility limitations statistically were no more likely to evacuate than shelter in place (21.2% vs 16.8%). Sensory impairments recorded for those households that report at least 1 adult with a sight disability that interferes with normal daily activities tend to be more common in senior shelter-in-place households than in adult households (8.6% vs 5.5%). Within senior households, those who evacuated were more likely to have sight limitations (11.8% vs 8.6%). Presented are also households who report having at least 1 member who has a limiting mental or cognitive disability such as dementia or Alzheimer disease. These conditions are more common in senior households who sheltered in place than in adult households who sheltered in place (1.9% vs 4.3%). There is no evidence that a larger share of senior shelter-in-place households than senior evacuated households evidence cognitive limitations (4.3% vs 5.9%). In sum, within senior households, the presence of sensory limitations appears more prevalent among those who evacuated while, contrary to theoretical expectations, mobility and cognitive limitations are not.

● Implications and Conclusions

Theory suggests that those households with elderly and medically fragile populations are least able to cope with storm-related disruptions to normal routines and, as such, are vulnerable to severe storm events. Evacuation is an appropriate mitigation action for these vulnerable populations and, all else equal, one may theorize that propensity to evacuate would be proportional to vulnerability. However, this research shows not only that elderly households are characterized by indicators of vulnerability but also that elderly households have a propensity to shelter in place at rates similar to less vulnerable populations. The propensity of these vulnerable populations to shelter in place in anticipation of an impending severe storm has immediate public health implications and may further exacerbate longer-term health disparities. Investment in interventions intended to address evacuation-related barriers, “prevents secondary conditions and institutionalization and reduces the use of scarce, expensive, and intensive emergency medical services.”⁴⁶

The US population continues to age⁴⁷ and during the next 2 decades, the number of American baby boomers who turn 65 will increase by 40%.⁴⁸ The elderly and those with medical needs, although often the most vulnerable to the immediate- and longer-term

TABLE 4 ● Home Medical Equipment and Propensity to Evacuate by Household Composition

			Household Composition	
			HH Solely With Adults 18-64	HH Solely With Seniors 65+
Electric medical equipment in home	Sheltered in place cv = .411, sig = .521	No electric med equip	89.3% (1986)	88.6% (1166)
		Electric med equip ^a	10.7% (238)	11.4% (150)
	Evacuated cv = .666, sig = .415	No electric med equip	89% (130)	85.7% (102)
		Electric med equip ^a	11.0% (16)	14.3% (17)

Abbreviations: CV, critical value; equip, equipment; HH, household; med, medical; sig, significance.

^acv = 2.082, sig = .156.

TABLE 5 ● Mobility, Sensory, and Cognitive Limitations and Propensity to Evacuate by Household Composition

		HH Composition		
		HH Solely With Adults 18-64	HH Solely With Seniors 65+	
Mobility (walking) limitation	Sheltered in place cv = 57.728, sig = .000	No mobility limitations Mobility limitations ^a	91.4% (2029) 8.6% (190)	83.2% (1093) 16.8% (221)
	Evacuated cv = 3.567, sig = .059	No mobility limitations Mobility limitations ^a	87.5% (126) 12.5% (18)	78.8% (93) 21.2% (25)
Sensory (sight) limitation	Sheltered in place cv = 12.813, sig = .000	No sight limitations Sight limitations ^b	94.5% (2098) 5.5% (122)	91.4% (1201) 8.6% (113)
	Evacuated cv = 5.430, sig = .020	No sight limitations Sight limitations ^b	95.9% (139) 4.1% (6)	88.2% (105) 11.8% (14)
Cognitive limitation	Sheltered in Place cv = 17.369, sig = .000	No cognitive limitations Cognitive limitations ^c	98.1% (2187) 1.9% (43)	95.7% (1261) 4.3% (57)
	Evacuated cv = 2.645, sig = .104	No cognitive limitations Cognitive limitations ^c	97.9% (143) 2.1% (3)	94.1% (112) 5.9% (7)

Abbreviations: CV, critical value; HH, household; sig, significance.

^acv = .298, sig = .571.

^bcv = 4.34, sig = .037.

^ccv = .791, sig = .371.

health impacts of a severe storm event, typically have a lower preparedness relative other groups.^{49,50} As these parsimonious descriptive statistics show, the presence of chronic conditions; ADL dependence; electric medical equipment; and mobility, cognitive, and sensory impairment are only on occasion modestly associated with household evacuation. The propensity to shelter in place in conjunction with the increased prevalence of functional limitations and disability within elderly populations needs to be recognized in planning, response, recovery, and mitigation efforts.^{18,33,45,51} The propensity to evacuate may be attenuated by other barriers such as transportation and social and familial networks, areas for future investigation.

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