



Departure time choice behavior for hurricane evacuation planning: The case of the understudied medically fragile population



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ABSTRACT

Despite the non-trivial number of (non-institutionalized) residents with special needs – referred to as the medically fragile population in this paper – there is virtually no research available to guide the hurricane evacuation planning for this population group. One area is their evacuation time choice behavior that can have tremendous implications for their safety as well as the logistics of the evacuation process. In this paper, we fundamentally advance our understanding of the evacuation timing behavior of this heavily understudied, and potentially vulnerable, population group. Analysis indicates that key differences exist between the medically fragile and non-medically fragile population.

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1. Introduction

The destructions caused by hurricanes to the coastal areas of the United States in recent years have signified the importance of developing effective evacuation policies and plans. In the past decade(s), extensive research has been conducted on the hurricane evacuation behavior in the United States (e.g. see Baker, 1991; Sorenson, 1991; Yin et al., 2013 and the references therein). Unfortunately, essentially all such studies focused on the behavior of the general population. Research on the behavior of people with health issues – in this paper referred to as the medically fragile population – is almost non-existent (Zhao et al., 2010; Ng et al., 2014). Considering the sizable fraction of the disabled population (12.1% of the United States' and 10.9% of the Commonwealth of Virginia's population), it should be clear that research focusing on this particular group is of paramount importance (U.S. Census, 2011; Erickson et al., 2012).

Numerous studies have emphasized the criticality to account for the special needs of the medically fragile during evacuations. For example, Litman (2006) pointed to the vital importance of appropriate accommodations for the ill and disabled during hurricane Katrina. He indicated that the most vulnerable population group was the citizens with disabilities. The criticality of effective communication to those with sensory disabilities was highlighted in a report by the National Council on Disability that cited congressional hearing testimonies explaining how people with disabilities had comprehension problems when evacuation instructions were given for hurricane Katrina and Rita. It also concluded that the majority of the fatalities were among the elderly and/or the disabled during hurricane Katrina (National Council on Disability, 2006). In the Virginia

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Hurricane Evacuation Guide, the state of Virginia emphasized the importance for a medically fragile resident to find a shelter that can accommodate his/her needs, and that (s)he should be registered with their local emergency management office (Virginia Department of Transportation, 2013). The general post-hurricane response is to have medical facilities setup that might lack certain accommodations that the medically fragile might need (Noji, 2001). The generalization of the population in terms of their needs during evacuations, and how these needs might vary from those with and without disabilities has been comprehensively highlighted in a report on behalf of the U.S. Department of Transportation and Federal Transit Administration (Zhao et al., 2010). In their report “Hurricane Evacuation Planning for Special Needs Population”, Zhao et al., identified vulnerability indicators associated with the residents of Miami-Dade county in Florida. One of their main findings was that much more research is needed on the special needs population.

To the best of our knowledge, the only two studies on the hurricane evacuation behavior of the *non-institutionalized* medically fragile population is by Van Willigen et al. (2002) and Ng et al. (2014). (Note that others have studied the *institutionalized* special needs population, who are inherently different from the non-institutionalized special needs population examined in this study, e.g. see Vogt, 1991, Brown et al., 2012 and Claver et al., 2013.) Van Willigen et al. (2002) analyzed and compared the unequal experiences that the disabled population had versus the non-disabled. For their research, they interviewed citizens with physical disabilities that lived in the coastal counties of North Carolina who experienced hurricanes Bonnie, Dennis, and Floyd. Their study focused on the difficulties associated with being disabled and how these conditions affected their evacuation decision process. Possible reasons for not evacuating were examined, in addition to perceived flood risk, property damage, the extent of the damage costs and hurricane planning. It was concluded that households that had a disabled member were affected differently than those without. More recently, Ng et al. (2014) examined determinants of evacuation for the medically fragile population and explicitly contrasted them with the general population. Again, critical differences were found to exist between the two population groups: having a strong network of family members, being a single parent household, the likelihood of neighborhood flooding and knowing the names of one's neighbors were found to affect the decision to evacuate rather differently for the two groups. (Note that others have conducted research on the evacuation departure times of the *general* population. Some representative examples of this prior work include Fu and Wilmot (2004, 2006), Lindell et al. (2005), Fu et al. (2006), Sadri et al. (2013) and Hasan et al. (2013))

To our knowledge, the departure time choice behavior in hurricane evacuations of the medically fragile population has never been studied thus far, whereas it can have tremendous implications for the safety of this population group as well as the logistics of the evacuation process. In this paper, we fundamentally advance our understanding of the evacuation behavior of the medically fragile population by scrutinizing the evacuation time choice behavior of this heavily understudied, and potentially vulnerable, population group using data collected from a large-scale survey in the Hampton Roads (HR) area. Both aggregate as well as disaggregate analysis (using the ordinal logistic regression model) have been conducted to uncover the differences between the medically fragile and non-medically fragile population.

The remainder of this paper is organized as follows. Section 2 contains the description of the data. In Section 3, we present and discuss the descriptive statistics of the variables under consideration with special focus on the differences between the medically fragile and non-medically fragile population. Ordinal logit models are then estimated in Section 4 to investigate the key differences in evacuation times between the medically fragile and non-medically fragile population. Section 5 concludes the paper with a summary, and various future research directions.

2. Data description

The data used in this study is from a large-scale household survey conducted within the HR region, 6–8 months after the landfall of hurricane Irene. Hurricane Irene made landfall in the Outer Banks of North Carolina and traveled through HR on August 27, 2011 as a Category 1 hurricane. HR encompasses 24 counties/cities (22 in Virginia and 2 in North Carolina) which include Accomack, Northampton, Middlesex, Lancaster, Northumberland, Richmond, Westmoreland, Gloucester, Mathews, James City, Chesapeake, Hampton, Isle of Wight County, Newport News, Norfolk, Poquoson, Portsmouth, Surry, Suffolk, Virginia Beach, Williamsburg, York County, Currituck County and Dare County (see Fig. 1). HR represents over 20% of Virginia's population (approximately 1.7 million residents), is home to the United States Navy Atlantic Fleet, houses a major cargo port, and is the most vulnerable area to flooding anywhere on the East Coast (Kaufman, 2010). Among the population of the Hampton Roads (HR), 10.1% of the population is considered disabled (Erickson et al., 2012).

Telephone interview surveys were conducted with 7068 households that were selected through a weighted (by population size) random sampling procedure among the 24 counties/cities. The survey contained questions regarding socio-economic characteristics, the impact of Irene, past hurricane experience and evacuation related decisions such as evacuation departure time. Most importantly, the survey contained extensive information on existing medical conditions among the members of the household, which makes this survey unique, both in terms of the size of the survey as well as the type of respondents. Table 1 shows the 14 medical condition related questions in the survey. Among the 7068 households in the survey, 599 households evacuated the HR region.

For now, a household for whom at least one of the questions in Table 1 apply/that affirmatively responded to at least one of the questions will be designated as a medically fragile household, as in Ng et al. (2014). (Another, narrower definition of medical fragility is adopted at the end of Section 4 in order to explore the sensitivity of our findings to alternative definitions.) It is to be noted that similar definitions have been used in the literature, e.g. see Van Willigen et al. (2002) who

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