BRIEF REPORT

Measuring and Comparing Hospital Accessibility for Palm Beach County's Elderly and Nonelderly Populations During a Hurricane

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ABSTRACT

Objectives: To determine whether, during a hurricane, geographic accessibility to hospitals with emergency care is compromised disproportionately for the elderly than for the nonelderly.

Methods: The locations of hospitals with emergency health care and a subset of those hospitals functional during a hurricane were compared with the distribution of the elderly population at the block group level in Palm Beach County, Florida. Geographic Information Systems (GIS) proximity analysis (minimum distance to closest hospital) and cumulative distribution functions were used to measure and compare hospital accessibility during normal and hurricane conditions for the elderly and nonelderly populations.

Results: Accessibility to closest functional hospital during a hurricane was compromised disproportionately for the elderly.

Conclusion: Geographic accessibility to emergency health care is compromised disproportionately for the elderly in Palm Beach County. Compounding the risk is the likelihood of the elderly experiencing a greater health care need during a hurricane. This poses a community public health crisis and calls for effective and collaborative planning between health professionals and disaster planners to address the health care needs of the elderly. (*Disaster Med Public Health Preparedness*. 2018;12:296-300)

Key Words: elderly, hospital accessibility, hurricanes, Geographic Information Systems

The rapid growth of the elderly population in the United States, coupled with the higher vulnerability and health care needs of the elderly during natural disasters, is an important issue of public health concern. From 2000 to 2010, the population aged 65 years and older grew at a much faster rate (15.1%) than the rest of the US population (9.7%), resulting in this age group making up an all-time high 13% of the total US population.[1] This trend will continue, and by 2060 the elderly will number an additional 42 million, constituting 24% of the total US population.[2] Many public health challenges associated with this demographic shift have been addressed by researchers.[3]

During disasters, the elderly experience higher incidences of trauma and mortality than do other age groups.[4] This is due to disaster-induced health challenges (such as mismanagement of chronic diseases and occurrence of acute health conditions) as well as socioeconomic constraints (such as lack of adequate preparation and poor adaptability).[5] Another contributing factor is compromised health resources related to facilities closures.[6] As Americans age, public health and emergency management policies must intersect to address the needs of the elderly during disasters.

With over 250,000 people above 65 years of age, Palm Beach County (PBC) in South Florida is 10th in the nation for elderly population.[7] PBC is 1 of 5 counties in the United States that has both high concentrations (≥3%) and substantial numbers (≥10,000) of those above 85 years of age.[7] Among the noninstitutionalized elderly population here, 28% live alone, 32% have disabilities, 44% live without marital partners, and 23% live below the poverty level.[8] These characteristics interact to increase the vulnerability of this population during disasters.

The dual realities of high hurricane risk and a large elderly population pose potentially serious emergency health care challenges for PBC. Post-disaster case studies (including studies on Hurricane Andrew) focusing on elderly vulnerability identified poor accessibility to medical care as an issue of concern.[9] Although geographic accessibility to health care is an established area of research, not many studies have examined disparities in accessibility for select population groups between normal and disaster scenarios. This study compared geographic accessibility to medical care between the elderly and nonelderly populations during normal and hurricane conditions. The objective was to determine whether a hurricane would disproportionately compromise accessibility of

the elderly population to hospitals with emergency care. These findings can help to formulate emergency management policies with an eye on elderly health care accessibility.

METHODS

Study Design

Geographic proximity to hospitals served as a proxy for accessibility. Spatial analysis of the elderly (age ≥ 65 years) and nonelderly (age < 65 years) population groups using urban block group demographic data from the American Community Survey (2009 to 2013) allowed the comparison of hospital accessibility during normal and hurricane conditions. The exclusion of rural block groups had a negligible impact on findings because only 1.6% of the total population and 0.5% of the elderly population resided there. A block group is a combination of census blocks within the same census tract and is the smallest geographic entity for which the census tabulates and publishes data. It usually covers a contiguous area and contains from 600 to 3000 people.

Hospital location data were available from state and county Geographic Information Systems (GIS) data portals. Hospitals from neighboring counties were included to eliminate border effects. The analysis for normal conditions included 38 general hospitals with emergency care facilities in PBC and neighboring counties. Two criteria excluded hospitals likely to experience functional disruption during hurricane conditions. First, hospitals in storm surge zones were excluded, as they are impacted by mandatory evacuation orders, inaccessibility due to flooding, malfunction due to power failures, and inability of staff to report for duty. Second, Hazus-MH, the damage estimation tool developed by the Federal Emergency Management Agency (FEMA), was used to exclude hospitals that are expected to have their function disrupted for at least 3 days during a 10-year hurricane. The 10-year hurricane is a reasonable estimate as PBC experiences a return period of 5 years for all hurricanes and 20 years for major (≥ category 3) hurricanes.[10] Hazus-MH estimates functionality loss by simulating wind conditions for probabilistic hurricanes and incorporating building attributes that would determine building response, damage, and loss. The comparison analysis of accessibility during hurricane conditions thus included a subset of 24 hospitals that are likely to continue to serve the population.

Measuring Accessibility

Geographic accessibility, in this analysis, was defined as proximity based on euclidean distance (ie, a straight-line distance between 2 points). The distance between each block group centroid and its closest functional hospital during normal and hurricane conditions was calculated by using minimum distance analysis. Given the increased incidents of health emergencies during a hurricane, distance to the closest hospital can impact the outcome of an emergency. A cumulative distance function graph was used to summarize the cumulative percentages of elderly and nonelderly populations at given distance threshold values. The graph provides a valuable visual comparison of accessibility for 100% of the elderly and nonelderly during hurricane and nonhurricane conditions.

Statistical Analyses

Block groups were categorized into quintiles of the percentage of the elderly (age ≥65 years) population (<20%, 20% to <40%, 40% to <60%, 60% to <80%, ≥80%). A one-way analysis of variance (ANOVA) was used to test the significance of differences in distance to the closest hospital between the block group quintiles during normal and hurricane conditions. Where the ANOVA test indicated significant differences between block group quintiles, a multiple comparisons test was used to identify which quintiles had significantly different mean distances from the others.

RESULTS

Hospital Distribution

Figure 1 maps the distributions of the hospitals in relation to the distribution of the elderly population. The hospitals exhibited a distinct north-south distribution that corresponded with the north-south pattern of population settlement here and seemed to provide adequate coverage during normal conditions. However, when hurricane-induced hospital malfunction was taken into account, the correspondence between the elderly population and hospitals with disrupted functionality was noticeable. The elderly population was concentrated along the coast and in inland southern PBC. Roughly 81% (11 of 14) of hospitals with disrupted functionality were also located within 5 miles of the coastline and in southern PBC. If hospitals with disrupted functionality are close to areas with a high elderly concentration, then hospital accessibility during a hurricane will be compromised disproportionately for this group. The results of the proximity analysis, discussed below, tested this possibility.

Distance to Closest Hospital

Figure 2a shows the average minimum distance to the closest hospital with emergency facilities for the block group quintiles during normal and hurricane conditions. During normal conditions the average minimum distance to the closest hospital was 2.5 miles for the entire study area. The value ranged from 2.4 miles to 2.6 miles across the block group quintiles. The Welch ANOVA, an unequal variance F test, did not reveal statistically significant differences in the minimum distance values for the block group quintiles [$F(4, 198.9) = 0.64$, P-value = 0.64]. Therefore, under normal conditions, distance to the closest hospital was comparable across the study area.

During hurricane conditions, average distance to the closest hospital increased from 2.5 miles to 4.2 miles. However, the

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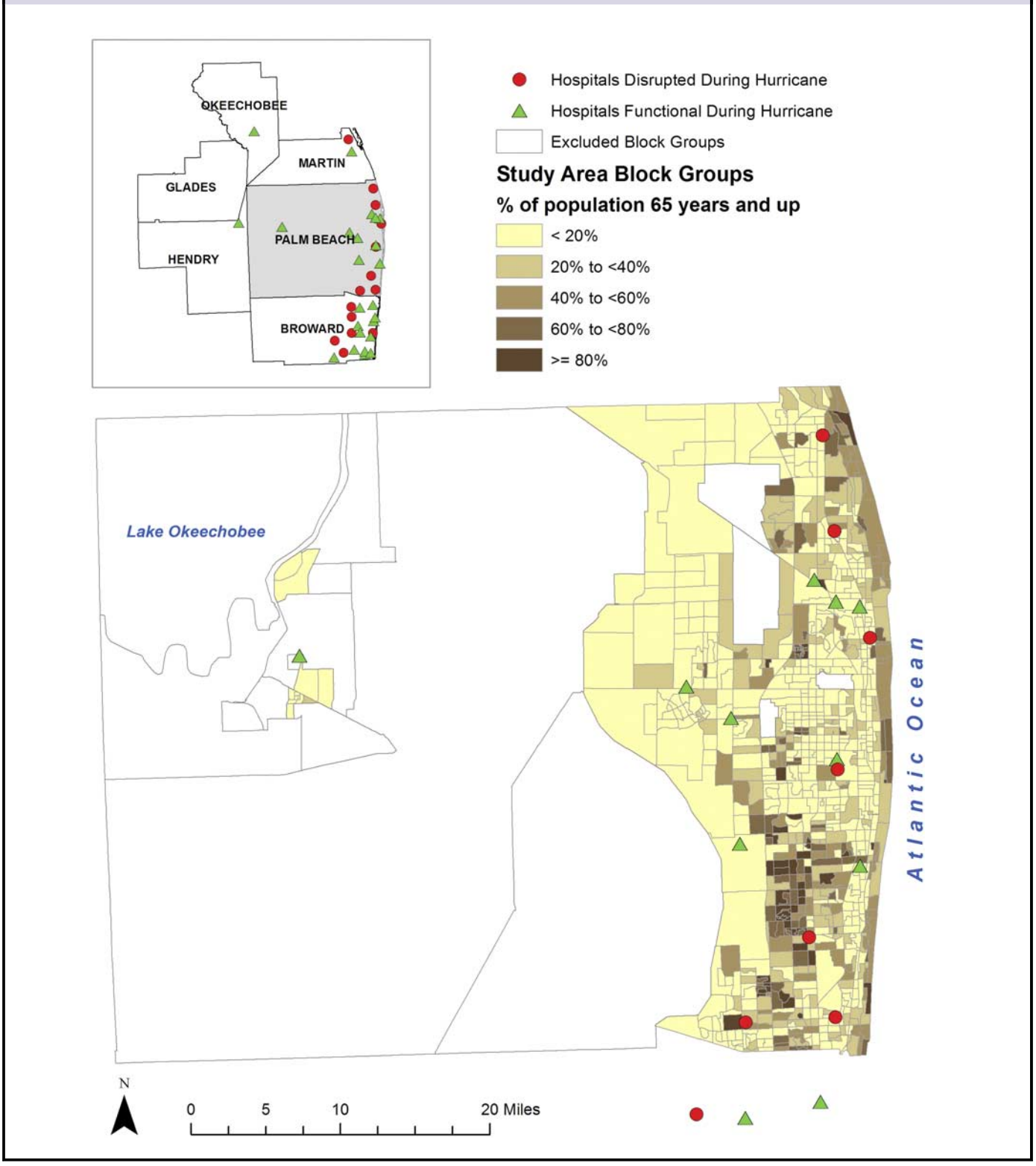
FIGURE 1

Hospital Locations and Distribution of Elderly Population by Block Group in Palm Beach County, Florida.



rate of increase varied across block groups. For block groups with <20% elderly, the mean distance increased from 2.6 miles to 4 miles, an increase of 54%. In contrast, for block groups with ≥80% elderly, the mean distance increased from 2.6 miles to 5 miles, a gain of 92%. There was a statistically significant difference between the 5 block group categories

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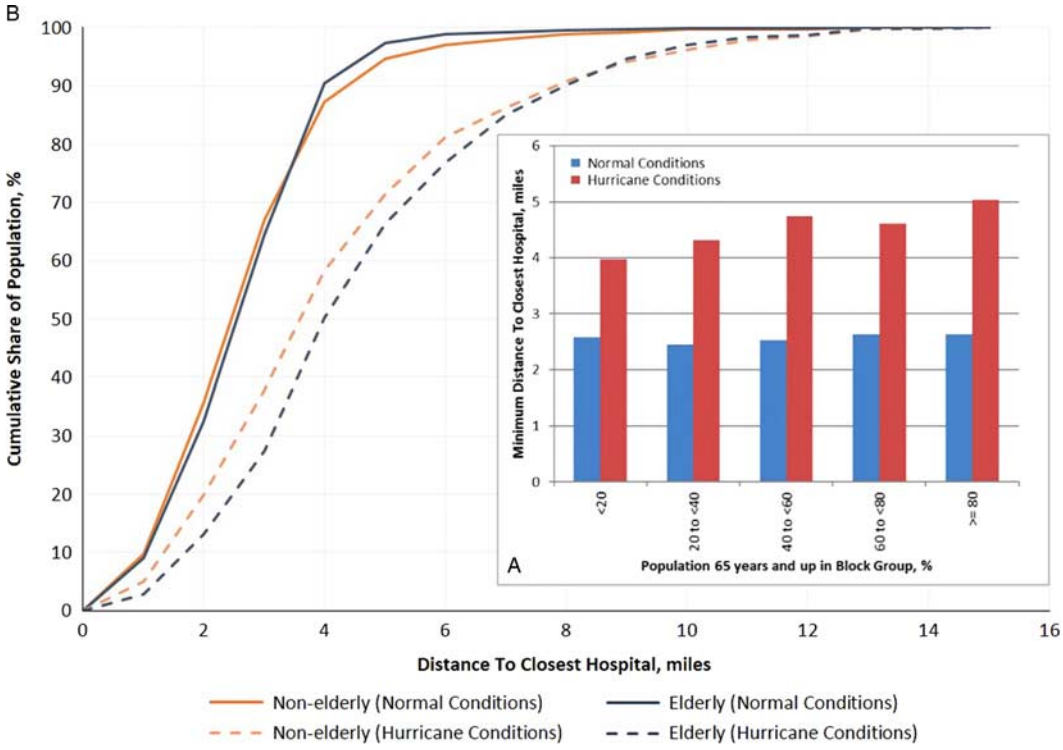
FIGURE 2

(A) Distance to Closest Functional Hospital During Normal and Hurricane Conditions for Block Group Quintiles Categorized by Percentage Elderly Population. (B) Cumulative Percentage Curves Comparing Minimum Distance to Closest Functional Hospital for Elderly and Nonelderly Populations During Normal and Hurricane Conditions.



as determined by one-way ANOVA [$F(4,865) = 4.38$, $P = 0.00$)]. Post-hoc comparison using the Bonferroni test revealed that the distance to the closest hospital was statistically significantly higher for block groups with ≥80% elderly (5.0 ± 2.1 miles, $P = 0.03$) and for block groups with 40% to 60% elderly (4.7 ± 2.4 miles, $P = 0.04$) compared to block groups with less than 20% elderly (4.0 ± 2.5 miles). There were no statistically significant differences between other pairs of block group categories.

In providing a visual basis for comparison between 2 groups (elderly vs nonelderly) under 2 situations (normal vs hurricane), the cumulative frequency curves (Figure 2b) emphasize the disproportionate impact of hurricane-related hospital malfunctions and closures on the elderly. During normal conditions, the curves for the elderly and nonelderly were virtually coincident. However, during hurricane conditions, the differences in the curves for the elderly and nonelderly were quite noticeable, especially for the first 5 miles. Compared to 20% of the nonelderly, only 13% of the elderly were within 2 miles of a functional hospital. For within 3 miles, the numbers were 38% for nonelderly and 27% for elderly. For within 4 miles, the numbers were 58% for nonelderly and 50% for elderly. Clearly, hospital malfunction causes a disproportionate impact on accessibility for the elderly.

DISCUSSION

The results of the present analysis suggest that during hurricanes, distance to the nearest functional hospital is indeed compromised disproportionately for the elderly. Average minimum distance to the closest hospital, which was comparable during normal conditions, was significantly higher for the elderly during hurricanes. Block groups with the highest proportion of the elderly (≥80%) experienced the greatest increase in distance: from 2.6 miles to 5.0 miles. This increase of 2.4 miles, in case of an emergency health care need, may mean the difference between life and death. The tendency of the elderly to reside in vulnerable coastal locations, to live alone, to resist calls for evacuation, and to suffer from mobility and health issues, translates into an enormous emergency health care challenge during a hurricane. Furthermore, one must note that the many impediments to travel during and in the immediate aftermath of a hurricane are likely to increase travel time by a much larger factor than that due to the increase in distance alone.

This study had several strengths. It used block groups, which are the smallest unit for which census data are available, as the unit of analysis. It excluded unpopulated and sparsely populated but geographically extensive rural block groups.

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This exclusion improved accessibility assessment and comparison, given that accessibility disparities exist between rural and urban areas. The study eliminated border effects by including hospitals in counties adjacent to the study area. Lastly, the study used both hospital location (within or outside the surge zone) and hospital building attributes (based on the FEMA Hazus-MH model) to determine hospital malfunction and inaccessibility.

This study had certain limitations also. It excluded factors (such as financial or transportation constraints) other than geographic proximity that can affect accessibility. The study used euclidean distance and not network-based distance to measure proximity. Network-based travel during a hurricane is unpredictable due to malfunction of traffic signals resulting from power outages as well as road closures associated with flooding, fallen trees, and evacuation planning. Hence, in order to facilitate comparison between normal and hurricane scenarios, euclidean distances are used. Another limitation is that the study did not compute and compare the round trip estimated time of an ambulance versus a one-way trip to an accessible hospital. A fourth limitation is that the study did not identify subgroups of elderly with differential vulnerabilities in different settings. It would, for example, be helpful to compare the functional capacity of elders living alone versus those in long-term care where some assistance could be rendered if residents shelter in place. Finally, the study did not distinguish between hospital sizes based on number of beds. An in-depth analysis can address these limitations.

CONCLUSIONS

Although public health research has studied many aspects of elderly health care needs, limited work has been undertaken on inequities in health care accessibility between the elderly and nonelderly during normal and disaster scenarios. This study sought to address that gap. Using the example of PBC in South Florida, this study has identified significant inequities in hospital accessibility for the elderly during a hurricane. Because these inequities do not exist normally, it is even more important that they do not go unheeded when disaster strikes. Despite some methodological limitations, the study supports the need for addressing the issue of elderly hospital accessibility during disasters. Disaster planning should be a collaborative effort involving emergency managers and professionals in health care and aging services. As more elderly Americans move to low-lying coastal communities, thereby increasing exposure to and higher negative outcomes from storms, it becomes important that their health care needs are not compromised due to poor accessibility to emergency health care. Results can be useful beyond PBC and can be replicated for cities that have a high hazards exposure and a sizable elderly population.

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