Racial disparities in pedestrian-related injury hospitalizations in the United States

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Abstract

Background. Racial/ethnic disparity has been documented in a wide variety of health outcomes, and environmental components are contributors. For example, food deserts have been tied to obesity rates. Pedestrian injuries are strongly tied to environmental factors, yet no studies have examined racial disparity in pedestrian injury rates. We examine a nationally-representative sample of pedestrian-related hospitalizations in the United States to identify differences in incidence, severity, and cost by race/ethnicity.

Methods. Patients with ICD diagnosis E-codes for pedestrian injuries were drawn from the United States Nationwide Inpatient Sample (2009-2016). Rates were calculated using the United States Census. Descriptive statistics and generalized linear regression were used to examine characteristics (age, sex, severity of illness, mortality rates, hospital admissions, length of stay, total costs) associated with hospitalizations for pedestrian injuries.

Results. Hospitalization rates were The burden of injury was higher among Black, Hispanic, and Multiracial/Other groups in terms of admission rates, costs per capita, proportion of children injured, and length of stay compared to Whites and Asian or Pacific Islander race/ethnicities. Extreme and major loss of function proportions were also highest among Black and Multiracial/Other groups.

Discussion. Results from this study show racial disparities in pedestrian injury hospitalizations and outcomes, particularly among Black, Hispanic, and Multiracial/Other race/ethnicity groups and support population and system-level approaches to prevention. Access to transportation is an indicator for health disparity, and these results indicate that access to safe transportation also shows inequity by race/ethnicity.

Introduction

Racial disparity has been well documented in a wide variety of health outcomes, ranging from infant mortality to asthma to diabetes to cardiovascular disease.\(^1\,^2\) Characteristics of the built environment have been identified as an important social determinant of health disparity, as well as disparity related to race/ethnicity.\(^3\) Examples include the relationships between food deserts and nutrition-related metabolic diseases, dilapidated neighborhoods and community violence, air pollution and
mortality, and zip code characteristics with cancer and overall mortality.\textsuperscript{4,5}

Environmental factors have been strongly tied to pedestrian injuries and deaths in all ages. Environmental risk factors include high speed roads, poor visibility, business density, wide roads, high traffic volume, and absence of pedestrian facilities (e.g. signals, refuge islands).\textsuperscript{6–8} However, the burden of injury from pedestrian hospitalizations by race/ethnicity has not been previously estimated. Based on studies that tie racial inequity in health outcomes to the underlying environmental conditions associated with low resources\textsuperscript{9}, we hypothesize that non-whites in the US have higher rates of pedestrian injury death and hospitalization. The objective of this study was to identify differences by race/ethnicity for pedestrian mortality rates and to examine incidence, severity, and cost of pedestrian-related injury hospitalizations in a nationally-representative sample.

Methods

Study Design and Data Sources

Data for mortality rates were from the Centers for Disease Control and Prevention Web-based Injury Statistics Query and Reporting System (WISQARS)\textsuperscript{10} for the years of 2009 to 2016. Data for hospitalizations from 2009 to 2016 were from the US Nationwide Inpatient Sample (NIS). The NIS, a nationally representative database of patient-level all-payer inpatient care, is part of the Healthcare Cost and Utilization Project, maintained by the Agency for Healthcare Research and Quality. The NIS includes sample weights based on hospital characteristics (ownership/control, bed size, teaching status, urban/rural location, and region) that can be used to calculate nationally representative estimates. Hospitalizations with primary or secondary diagnosis external cause of injury e-codes corresponding to pedestrian injuries were included as part of the study sample. Data for rate denominators were from the United States Census total population for each race/ethnic group. Populations for the Census Hispanic categories were aggregated to match the Hispanic definition used by the NIS. Native American was included in the Multiracial/Other category due to low counts.

Study variables

The primary dependent variable was total hospital costs. Hospital charges were converted to costs by using the cost-to-charge ratio files provided by the NIS and adjusted to inflation rates for in-hospital...
care for Q4 of 2016 based on Bureau of Labor Statistics data. Cost per capita by race/ethnicity was computed as the estimated total hospital costs for each race/ethnic group divided by the corresponding total census population estimate of that group. This quantity is interpreted as the dollar amount burden of pedestrian injuries per person in each race/ethnicity group.

We also descriptively examined the following outcomes: length of stay (days), severity of illness, and mortality (died indicated in discharge disposition). Severity of illness was based on the Patient Diagnostic Related Group Severity of Illness variable in the NIS dataset, which includes the following categories: extreme, major, moderate, and minor loss of function.

The primary independent variable was race/ethnicity (Black, Hispanic, Asian or Pacific Islander, White, and Multiracial/Other). Native Americans and anyone identifying as multi-racial were included in the Multiracial/Other category. Interactions between age, sex, and race were examined and it was determined by QIC that a model with only main effects for these variables best fit the data.

Analysis
National estimates of frequencies and proportions were calculated for all patient and hospital characteristics of interest (age, sex, severity of illness, mortality rates, hospital admissions, length of stay and total costs) by race/ethnic group. Generalized Estimating Equations (GEE) based on the gamma distribution with an exchangeable working correlation matrix were used to estimate hospital costs per admission adjusted for patient and hospital level characteristics (age, sex, length of stay, severity of illness, income, payer source, indicator for ICD-9 vs. ICD-10, hospital region, & hospital location/teaching status). All estimates incorporated NIS sampling weights and the NIS sampling design to provide nationally representative estimates and standard errors. SAS 9.4 was used for all statistical analyses.

Results
For the years 2009 to 2016, there were 40,576 deaths and 376,417 total estimated hospitalizations for pedestrian-related injuries in the United States. Annually, that translates to an average of more than 47,000 pedestrian-related hospitalizations in the United States, accounting for an estimated $1.13 billion in total hospital costs per year. The number of pedestrian-related deaths increased from
4,109 in 2009 to 6,348 in 2016, while the estimated number of hospitalizations decreased from 47,389 in 2009 to 36,620 in 2016.

Pedestrian mortality rates per 100,000 population (Figure 1) were highest for Multiracial/Others (2.44) and Blacks (2.78). Rates of hospital admissions (Figure 1) were higher for Blacks (15.6) and Multiracial/Other (24.9) compared to Whites (13.0), Hispanics (11.8), and Asian or Pacific Islander (8.3) race/ethnicities.

Compared to Whites, the rate of hospital admissions were 1.92 and 1.20 times higher for Multiracial/Other and Blacks, respectively. Whereas, the rate of hospital admissions were 36% (Rate Ratio = 0.64, 95% CI = 0.63-0.65) and 9% (Rate Ratio = 0.91, 95% CI = 0.90-0.92) lower for Asian or Pacific Islander and Hispanics, respectively.

Black, Hispanic, and Multiracial/Other groups had higher costs per capita (Table 1). Pedestrian hospitalizations carry a burden of $4.14, $3.22, and $6.30 per capita for Blacks, Hispanics, and Multiracial/Others, compared to $2.88 and $2.32 for Whites and Asian or Pacific Islanders. Higher proportions of children and young people (ages 24 and under) were injured among Black (32.5%), Hispanic (35.8%), and Multiracial/Other (30.7%) groups, compared to White (21.9%) and Asian or Pacific Islander (22.8%). However, these patterns are as expected, as young people make up a greater proportion of the population among those race/ethnic group. Compared to Whites, all other race/ethnicities had more lengths of stay exceeding one week. Extreme and major loss of function proportions were also higher among Blacks compared to other race/ethnicities.

Compared to Whites, all other race/ethnic groups had higher adjusted hospital costs (Table 2). Furthermore, adjusted hospital costs by each payer source (government, private, other) were lower for Whites compared to all other combinations of race and payer source, with the exception of self-pay.

**Discussion**

Racial disparities in pedestrian deaths and injuries were present in both incidence rates and outcomes. Mortality rates among Black, Hispanic, and Multiracial/Other and hospitalization rates among Black and Multiracial/Other race/ethnicity groups were particularly high compared to White
and Asian or Pacific Islanders. The Black, Hispanic, and Multiracial/Other race/ethnic groups carry a larger burden of injury with increased hospital costs, cost per capita, severity of illness, and lengths of stay. Differential exposure to walking, and in particular risky pedestrian environments, are likely a major contributor to these differences (i.e., time spent walking and exposed to traffic). However, accurate pedestrian exposure data by race/ethnicity are not available but are important for understanding the mechanisms behind these disparities.

Results from this study align with a large body of literature related to racial disparities and health outcomes which has consistently showed disparities among Black, Hispanic, and Multiracial/Other race/ethnicities, compared to Whites.\textsuperscript{13,14} Our results are also in agreement with previous research that has established links between race and inequities in safety and accessibility of transportation, including walking,\textsuperscript{15} and neighborhood social inequities, traffic volumes, road design, and road traffic injuries.\textsuperscript{8} For example, a study of nearly 50,000 U.S. pedestrian deaths using CDC annual mortality data (1999–2015) found significant disparities in death rates by racial/ethnic groups, with higher rates among Blacks, Latinos, and Native Americans, compared to Whites.\textsuperscript{16} Our results add to the literature by further showing disparities in injury severity and burden of injury from pedestrian hospitalizations in terms of costs, length of stay, and discharge disposition.

Access to transportation is a recognized social determinant of health, but disparities and inequities in transportation access and safety have largely been overlooked, despite having important ramifications related to health and well-being (access to food, jobs, etc.).\textsuperscript{17} The persistence and variety of health outcomes which demonstrate racial disparity indicate that the focus of prevention would best be placed at the population-level and on systems-based factors, rather than at the individual level or on issues related to race/ethnicity directly.\textsuperscript{18,19} These factors include economic, built environment, and transportation policy changes and interventions. Specific to reducing the burden from pedestrian injuries, this may include resolving inequities in transportation access, improvements to the built environment to include pedestrian facilities (e.g., crosswalks, pedestrian signals), and other safety features (e.g., geographic equity in repair and maintenance of roads and
sidewalks). Results from this study show that the burden of injury from pedestrian injuries is higher among non-Whites, which has important implications in development of prevention and intervention approaches as we work to combat the rising pedestrian fatality and injury toll in the United States.

Conclusions
This study adds to growing evidence of the ties between the physical environment and health. The persistence of racial disparities in health outcomes indicates priority for prevention approaches at the population and systems-level, as opposed to individual-level approaches. Thus, access to safe transportation should be integrated into transportation policy and infrastructure decisions.

Declarations

Ethics approval: This study was determined to be exempted from Human Subject Office review because the data are publicly available and de-identified. This determination was made by the University of Iowa Human Subject Office.

Consent for Publication: not applicable.

Availability of data and materials: The National Inpatient Sample is available through the Healthcare Utilization Project of the Agency for Healthcare Research and Quality: https://www.hcup-us.ahrq.gov/nisoverview.jsp.

Competing interests: Authors have no competing interests.

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Author’s contributions: CH supervised manuscript development and preparation. BB conducted analysis and drafted methods and results sections. CPA conceived the study question and participated in drafting and finalizing the manuscript.

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Tables
Due to technical limitations, all Tables 1 & 2 are only available for download from the Supplementary Files section.

Figures

Figure 1
Mortality rate of pedestrian injuries per 100,000 census population from WISQARS and Hospitalization rate per 100,000 census population estimated from HCUP-NIS, 2009-2016.
Figure 2

Annual hospitalization admission rates by race estimated from HCUP-NIS, 2009-2016.

Supplementary Files
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Tables.docx