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Research Article

What Doesn't Kill You Doesn't Make You Stronger: The Long-Term Consequences of Nonfatal Injury for Older Adults

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Abstract

Purpose: The majority of research efforts centering on injury among older adults focus on fall-related injuries and short-term consequences of injury. Little is known about the long-term consequences of all-cause nonfatal injuries, including minor injuries. Using a recent, large, and nationally representative sample of the U.S. non-institutionalized civilian population, the current study examines whether older adults who sustained a nonfatal injury (serious and minor) have higher risk of long-term morbidity and mortality outcomes compared with noninjured seniors.
Methods: Linked National Health Interview Survey-Medical Expenditure Panel Survey (NHIS-MEPS) data were used to fit logistic and 2-part models to estimate associations between injury incidence and later injury, hospitalization incidence, and length of hospital stay during the 2.5 years following the NHIS interview among 16,109 older adults. Data from the linked National Health Interview Survey-National Death Index (NHIS-NDI) files were used to estimate a Cox proportional hazards model to examine the association between injury incidence and mortality for up to 11 years after the initial interview among 79,504 older adults.
Results: Relative to no injury, serious nonfatal injury was significantly associated with increased risk of another injury, hospitalization, and mortality. Minor injuries were significantly related to higher risk of later injury and mortality.
Implications: Because even minor injuries are strongly associated with increased risks of later injury and mortality, preventing injury among seniors may be an effective way to improve quality of life and reduce declines in functional capacity.

Keywords: Analysis: Regression models, Analysis: Survival analysis, Health, Death and dying, Hospital/ambulatory care

Injuries are a leading cause of death among older adults in the United States. Their magnitude is on par with deaths from Alzheimer's disease, diabetes, and influenza (Dellinger & Stevens, 2006), and fatal and nonfatal injuries incur annual costs of more than $40 billion in direct medical care (CDC, 2014b). The impact of injuries on quality of life for older adults may be even greater than what can be expressed in terms of immediate mortality and cost of injuries. Nonfatal injuries may result in a cascade of other health consequences, such as functional limitations or a fear of reinjury, that can negatively impact emotional and mental health, social role functioning, pain, and other quality of life domains, increase frailty, decrease the ability to live independently, and increase the chances of premature death (Carter & Porell, 2011; Inaba, Goecke, Sharkey, & Brenneman, 2003; Noro & Aro, 1996; Porell & Carter, 2012;

Stevens, Corso, Finkelstein, & Miller, 2006; Tinetti & Williams, 1997; Vellas, Wayne, Romero, Baumgartner, & Garry, 1997; Yang, Norton, & Stearns, 2003).

All-cause nonfatal injury among older adults has not received much attention in prior research. The majority of research and prevention efforts centering on injury among older adults has focused on fall-related injuries, which constitute 60% of all nonfatal injuries among community-dwelling older adults (Xu & Drew, 2016). As a result, we know little about overall patterns in nonfatal injury consequences for older adults. Of existing research, most examined short-term consequences of all-cause injury, such as costs of health care received immediately following injury (Finkelstein, Chen, Miller, Corso, & Stevens, 2005) or 30-day in-hospital mortality following injury (Gorra, Clark, & Mullins, 2011). The few studies characterizing the long-term consequences of nonfatal injuries among older adults found that nonfatal injuries led to several long-term consequences, spanning health-related quality of life (Inaba et al., 2003), medical care spending (Carter & Porell, 2011), institutionalization (Porell & Carter, 2012), and death (Porell & Carter, 2012). Serious nonfatal injury resulted in significantly reduced health-related quality of life and declines in independent living among older adults (Inaba et al., 2003). Serious injuries—regardless of hospitalization status and baseline characteristics such as age, health status, and functional limitation—also dramatically increased Medicare spending on both injury and noninjury-related health care for at least several years after injury incidence (Carter & Porell, 2011). We found only one study (Porell & Carter, 2012) that examined the long-term consequences of all-cause nonfatal injuries including minor injuries. This study used a sample of 12,031 participants with continuous Medicare eligibility not enrolled in managed care who entered the Medicare Current Beneficiary Study between 1998 and 2001, and followed participants for 4 years following study entry. They found that serious nonfatal injuries raised the short- and long-term risks of institutionalization and mortality. Minor injuries did not raise short-term mortality or long-term institutionalization risk, but did raise the risks of short-term institutionalization and dying within 4 years of injury incidence. Although this study considered institutionalization and mortality risk, it did not consider other possible outcomes such as the risk of another injury or hospitalization risk and investigated mortality risks over a relatively short period of time.

We argue for the importance of assessing the long-term consequences of both serious and minor all-cause nonfatal injuries among older adults for three reasons. First, by excluding consideration of minor injuries, we ignore a large share of injuries sustained by older adults. More than 80% of medically attended nonfatal injuries do not result in hospitalization (Xu & Drew, 2016) and in 2014, nearly 75% of older adults seeking care from an emergency room for their injuries were treated and released without hospitalization (CDC, 2016b). Second, studies of minor all-cause injuries and specific injury demonstrate that minor injuries are associated with long-term declines in physical functioning, even after controlling for baseline health status (Edwards, Song, Dunlop, Fink, & Cauley, 2010; Porell & Carter, 2012). The after-effects of minor injuries may resemble those of severe injuries, and similar health burdens may lead to morbidity and mortality consequences akin to those observed among older adult survivors of serious injuries (Carter & Porell, 2011). Third, making minor injuries the target of public health intervention may present a significant opportunity to reduce nonfatal injury impacts: one of the most important predictors of falls is a previous fall (Asada et al., 1996; Bergland & Wyller, 2004; Tromp et al., 2001; Yamashita, Noe, & Bailer, 2012).

We extend previous research on the long-term consequences of minor and serious all-cause nonfatal injury in several ways. First, we consider the incidence of additional injury and later hospitalization as key outcomes, in addition to mortality. In 2013, older adults accounted for 35% of all hospitalizations (U.S. Department of Health and Human Services, 2016a), but only 14% of the U.S. population (U.S. Census Bureau, 2014). Their hospital stays were longer on average compared with younger hospital patients and resulted in more than 42% of the national hospital bill in 2011 (Weiss, Barrett, & Andrews, 2014). The hypothesized mechanism linking nonfatal injuries with later health and mortality consequences is a possible long-term or permanent reduction in health status and/or functional capacity (Inaba et al., 2003; McGwin, MacLennan, Fife, Davis, & Rue, 2004; Tinetti & Williams, 1998) making individuals less resilient to additional health insults. Injurious events, such as falls, episodes of overexertion, or motor vehicle accidents, can produce contusions, open wounds, sprains, or fractures that lead to pain, fatigue, and limitations in balance, mobility, grasp, reach, and strength (Inaba et al., 2003; Tinetti & Williams, 1998). Beyond physical limitations, injured persons can engage in further restriction of activity due to a fear of re-injury (Zijlstra et al., 2007), engendering, or compounding declines in emotional and psychological wellbeing and social role functioning (Inaba et al., 2003). Reduced health status, functional capacity, and mental wellbeing resulting from injury can lead to a diminished ability to withstand health complications resulting from injuries, like infections or skin ulcers, and make it less likely to recover baseline functional capacity and health (Holbrook, Anderson, Sieber, Browner, & Hoyt, 1999). We argue that this potentially long-term drop in functioning and resilience can heighten the risk of additional injury and major episodes of health care. Through this same pathway, nonfatal injury may also reduce the number of remaining years of life, leading to premature mortality (Porell & Carter, 2012; Richmond, Kauder, Strumpf, & Meredith, 2002). Examining how nonfatal injury may be related to later health and mortality consequences is especially relevant for older adults; they may experience a more severe and persistent increase in frailty compared to younger individuals, and the decline in health may be more likely to be permanent.

Second, we extend the period of mortality follow-up by drawing upon survey data linked to the National Death Index

(NDI), allowing us to observe deaths occurring up to 11 years after the initial interview. Third, we use a recent, large, and nationally representative sample of the U.S. noninstitutionalized civilian population. In addition, this study examines the risk of later injury, hospitalization incidence and duration, and mortality for older adults who sustained a nonfatal injury (serious and minor) compared to non-injured older adults.

Methods

Data and Samples

This study uses an integrated version of the public use National Health Interview Survey (NHIS) produced by the Integrated Health Interview Series (MPC and SHADAC, 2016). The NHIS is a cross-sectional, annual survey, collecting information from a nationally representative sample of the U.S. civilian non-institutionalized population (CDC, 2014a). Information on the health and health care utilization of each family member is collected from a family respondent, and additional information is collected about injuries for all family members identified as having experienced at least one medically attended injury in the 3 months prior to the survey.

Our samples consist of participants aged 65 years and older at the time of the NHIS survey that could be linked to two different longitudinal data sources. The first, the Household Component of the Medical Expenditure Panel Survey (MEPS), selects a subsample of households who participated in the previous year's NHIS and collects information on household members an additional 5 times over a 2.5-year period on topics related to health, health care utilization, and health care expenditures (U.S. Department of Health and Human Services, 2016b). After limiting the sample to NHIS participants who (1) could be linked to the MEPS, (2) participated in all five MEPS interviews or participated in some interviews but could not participate in others due to death, institutionalization, or a move outside of the United States, and (3) had full information on all analysis variables for at least one MEPS interview, our final sample size for the re-injury and hospitalization analyses totaled 16,109 older adults. We retained 855 individuals who had died (634), were institutionalized for all or part of the MEPS data collection (204), or had moved outside of the United States (17). We excluded 788 people, or 4.7% of cases, due to missing data. The second longitudinal data source is the NDI, a database of death certificate records containing information on calendar quarter and year of death and cause of death. Staff at the National Center for Health Statistics used a set of uniquely identifying information to match NHIS respondents to death certificate records in the NDI database, including Social Security Number, last name, date of birth, father's surname, and state of birth (NCHS, 2009). The linked NHIS-NDI public use files were updated in 2015 to include NHIS respondents surveyed between 1986 and 2009 and death certificate data through December 31, 2011 (CDC, 2016a). From 81,597 older participants with linked NHIS-NDI data, we excluded 2.6% (n = 2,093) with missing information on education. A total of 79,504 older adults were used to estimate mortality risk.

To estimate associations between minor and serious injury incidence and risks of later injury and hospitalization, we used data from 2001 to 2011 NHIS family questionnaire and injury supplement linked to data from 2002 to 2013 MEPS full-year consolidated and medical conditions files. To estimate the associations between injury incidence and later mortality, we used the linked NHIS-NDI file limited to participants in the 2001–2009 NHIS surveys.

Measures

Injury

Injury refers to the traumatic event in which a person was harmed seriously enough by an external cause to seek medical advice or treatment in the past 3 months. Examples of injury causes include falls, motor vehicle accidents, overexertion, burns, and cuts, among other causes, and injury consequences range from minor contusions and lacerations to more serious head injuries and fractures. For analyses examining the association between nonfatal injury incidence observed in the NHIS and later morbidity and mortality outcomes, we constructed a three-category variable: serious injury (injury treated in an ER or hospital), minor injury (injury treated in a doctor's office, or via a call to a medical professional), and no injury (no injury reported at the time of the NHIS). For sampled persons with more than one injury, all minor, the timing of the first injury was used. For those who had at least one serious injury, the timing of the first serious injury was used. These cases were relatively rare: 96% of injured persons in our sample had only one injury.

Morbidity Consequences

We constructed three measures of morbidity consequences: (a) an accident or injury resulting in a medical condition linked to a disability bed day, that required medical attention in the current year (prescription medication, office-based, outpatient, or ER visit, hospitalization, and/or home health care), or that was categorized as a priority medical condition by MEPS (conditions identified due to their high prevalence, medical expense, or policy relevance) during the 2.5-year MEPS follow-up period after the NHIS interview; (b) any nights in the hospital during the MEPS follow-up; and (c) number of nights in the hospital during the MEPS follow-up.

Mortality

Time was measured in person-calendar quarters, with duration beginning the calendar quarter prior to the NHIS interview. This timing of risk onset was selected because NHIS respondents reported injuries occurring in the 3 months before the NHIS interview. The outcome of interest is the quarter of death; the NHIS-NDI file only provides the quarter and year of death for decedents.

Control Variables

Aside from the three-category injury variable described above, control variables included categorical age (65–69, 70–74, 75–79, 80–84, and 85+), sex, race/ethnicity (non-Hispanic white, non-Hispanic black, other), and education (less than high school, high school graduate, some college, 4-year college graduate). In sensitivity analyses, we considered a measure of health status at the time of the NHIS survey (measured as fair or poor health versus good, very good, or excellent health). We dropped health status from the final set of models because the results were similar to our initial models and it may have attenuated the relationship between injury and outcomes since it is possible that poorer health status at the time of the NHIS interview resulted from the injury.

Analysis

Associations between injury and the risk of another injury during the follow-up period were assessed using a binary logistic regression model. The risk and duration of hospitalization were evaluated using a two-part model: the first stage used a logit model to predict the risk of any hospitalization, and the second used a generalized linear model with a log link and gamma distribution to predict the total number of nights spent in the hospital for those who were hospitalized (Belotti, Deb, Manning, & Norton, 2015). After fitting the two-part model predicting hospitalization risk and duration, we predicted the marginal effect of injury on number of hospital nights based on both parts of the two-part model; that is, the predicted probability of hospitalization (the first part) multiplied by the predicted average number of hospital nights among those hospitalized (the second part).

Associations between injury incidence and later mortality were assessed using a Cox proportional hazards model. We performed a test of the proportional hazards assumption that demonstrated the assumption held for the three-category injury variable and the majority of covariates included in the model. However, the assumption did not hold for sex (p = .0041) and some college education (p = .0113), and the global test indicated the assumption did not hold (p = .0003). Alternative models stratified by sex and education and allowing the relative hazards of sex and education to vary as a function of time and log time produced identical results, indicating that the estimated associations between injury and mortality were not influenced by violations of the proportional hazards assumption (Cleves, Gutierrez, Gould, & Marchenko, 2010).

Survival rates for the 11 years after injury onset were estimated using Kaplan–Meier methods. All models were adjusted for age, sex, race/ethnicity, and education level (measured as described above). All estimates were population weighted and standard errors adjusted for complex survey design using the Stata svy commands; the morbidity models used the MEPS longitudinal weight and the mortality models used the person mortality weight. All statistical analyses were performed using Stata 12.1. Statistical significance was accepted at the $p < .05$ level.

Results

Population-weighted characteristics of community-dwelling older adults from the linked NHIS-MEPS sample and the linked NHIS-NDI sample are presented in Tables 1 and 2, respectively. The demographic and educational composition of the two analytic samples was very similar. The mean age was approximately 74 years of age and those who were injured (regardless of severity) were older than those without injury by 1 year, on average. The proportion of older adults with injuries at baseline who were 85 years of age or older was twice as large as it was for noninjured older adults. Roughly 57% were female, and the female share increased with injury severity. Approximately 82% were non-Hispanic white, with those who had injuries at baseline having a slightly larger share that were non-Hispanic white. There was no clear pattern of injury by level of education; those with any injury had a larger share of people with some college education than those with no injury, but a smaller share of those with injuries at baseline had attained only a high school education relative to the noninjured.

Injury Incidence and Risk of Subsequent Injury Incidence and Hospitalization Episodes

For those with serious injury, 42.9% were reinjured, 45.1% had at least one hospital stay, and 17.5% spent 10 or more nights in the hospital during the follow-up period (Table 1). Of those who sustained minor injuries, 37.8% were subsequently injured, 39% experienced a hospital stay, and 13.5% spent at least 10 nights in the hospital. For those with no injury at baseline, 26.2% were injured during the MEPS follow-up, 30.1% experienced a hospital stay, and 9.2% spent at least 10 nights in the hospital.

In Table 3, we present coefficients but we convert the coefficients into odds ratios for easier interpretation in our report of the model results. After adjusting for differences in age, sex, race/ethnicity, and education, having been seriously injured around the time of the NHIS interview was associated with a doubling of the odds of sustaining another injury during the follow-up period (Table 3, column 1, odds ratio = 1.995). Minor injury at baseline also significantly increased the odds of sustaining another injury relative to no injury at baseline (odds ratio = 1.589). Serious injury was also associated with a significantly higher odds of hospitalization during the follow-up period (refer to Table 3, column 2, odds ratio = 1.843). However, serious injury did not significantly increase the number of nights in the hospital compared to older adults who were hospitalized but did not have an injury at baseline (Table 3, column 3). Having a minor injury did not significantly increase the odds of hospitalization or hospitalization duration relative to having no injury at baseline. The average effect of having

Table 1. Characteristics of the Linked NHIS-MEPS Sample, 2001–2011: Adults Age 65+ by Injury Status at the Time of the NHIS Interview

	All		No injury		Minor injury		Serious injury	
	%	95% CI	%	95% CI	%	95% CI	%	95% CI
Hospital nights (mean)	3.3	(3.1, 3.5)	3.2	(3.0, 3.4)	4.6	(2.7, 6.5)	4.9	(3.6, 6.3)
None	69.5	(68.6, 70.4)	69.9	(69.0, 70.8)	61.0	(51.7, 70.3)	54.9	(47.4, 62.3)
1–3 nights	11.6	(10.9, 12.2)	11.4	(10.8, 12.0)	17.1	(10.7, 23.7)	16.0	(10.4, 21.6)
4–9 nights	9.6	(9.0, 10.1)	9.5	(9.0, 10.1)	8.4	(3.7, 13.0)	11.7	(7.3, 16.0)
10+ nights	9.4	(8.8, 9.9)	9.2	(8.6, 9.7)	13.5	(7.8, 19.2)	17.5	(11.7, 23.3)
Subsequent injury	26.6	(25.8, 27.5)	26.2	(25.3, 27.1)	37.8	(29.5, 46.2)	42.9	(35.3, 50.4)
Age (mean)	74.1	(73.9, 74.2)	74.0	(73.9, 74.2)	75.4	(74.3, 76.6)	75.3	(74.3, 76.4)
65–69	30.4	(29.4, 31.4)	30.6	(29.6, 31.6)	23.7	(16.6, 30.8)	24.3	(17.7, 30.8)
70–74	24.9	(24.0, 25.7)	24.9	(24.0, 25.8)	23.3	(16.6, 30.0)	23.0	(17.0, 29.1)
75–79	20.9	(20.0, 21.7)	20.8	(20.0, 21.7)	20.7	(13.7, 27.7)	22.7	(16.3, 29.2)
80–84	14.7	(13.9, 15.5)	14.7	(13.9, 15.5)	14.4	(9.3, 19.5)	13.7	(8.6, 18.8)
≥85	9.1	(8.5, 9.7)	8.9	(8.3, 9.5)	17.9	(10.5, 25.2)	16.3	(10.0, 22.5)
Female	57.5	(56.7, 58.2)	57.3	(56.5, 58.1)	61.6	(53.2, 69.9)	66.3	(60.3, 72.4)
Race/ethnicity								
White	81.8	(80.5, 83.0)	81.6	(80.4, 82.9)	86.4	(81.8, 91.0)	84.6	(80.3, 88.9)
Black	8.0	(7.3, 8.7)	8.1	(7.4, 8.8)	5.3	(2.3, 8.3)	6.1	(3.4, 8.7)
Other	10.2	(9.2, 11.3)	10.3	(9.2, 11.4)	8.3	(4.2, 12.4)	9.3	(5.9, 12.8)
Education								
Less than HS	20.9	(19.9, 21.9)	20.9	(19.9, 21.9)	16.6	(10.5, 22.7)	21.8	(16.4, 27.2)
HS grad	34.7	(33.7, 35.7)	34.8	(33.8, 35.8)	31.0	(22.8, 39.2)	32.8	(26.5, 39.0)
Some college	22.3	(21.4, 23.2)	22.3	(21.4, 23.1)	25.6	(17.3, 33.9)	24.3	(18.1, 30.5)
College grad	22.1	(21.0, 23.2)	22.0	(20.9, 23.2)	26.8	(19.2, 34.4)	21.1	(14.6, 27.7)
Unweighted *N*	16,109		15,661		189		259	

sustained a serious injury when compared with no injury at baseline was an increase in hospital duration of 1.51 nights (Table 4). The average effect estimated from the two-part model may seem counterintuitive because there was no statistically significant association between serious injury and hospital duration among those who were hospitalized. We interpret this average effect to mean that the increased risk of any hospitalization experienced by those with serious injury at baseline was associated with an average increase of 1.5 inpatient hospital nights due to the relatively higher frequency of hospitalizations, although the length of hospital stays did not differ by baseline injury status. Women were significantly more likely than men to sustain another injury, but less likely to be hospitalized. The risk of subsequent injury and hospitalization increased in age groups 75 and older, and the magnitude of the risk increased with age. Education had no effect on subsequent injury, but higher levels of education were associated with a reduction in the risk of hospitalization. Relative to older adults with less than a high school education, the average effect of a college education was a decrease in hospital length of 2.07 nights. Non-Hispanic blacks and other race/ethnicity seniors were significantly less likely to sustain another injury compared to non-Hispanic whites. Non-Hispanic blacks experienced hospitalization risk equal to that faced by non-Hispanic whites but were more likely to spend a longer period of time in the hospital when hospitalized. Other race/ethnicity seniors were significantly less likely to experience a hospitalization, but experienced a similar number of inpatient hospital nights to non-Hispanic whites when hospitalized.

Injury and Mortality Risk

There was a clear difference in mortality risk by injury status. More than 38% of seriously injured older adults died within 11 years (Table 2), 27.9% of those with minor injuries died, and 24.9% of those with no injury at baseline died. In Kaplan–Meier estimates of the unadjusted cumulative probability of survival (Figure 1), we found that survival time for seriously injured older adults was significantly shorter when compared with survival times for the minor and no injury groups. The survival time for the minor injury group was also significantly shorter than for the noninjury group. The probability of death for seriously injured older adults reached 25% by 14 quarters (or 3.5 years) after baseline, by 21 quarters (or 5.25 years) in minor injury group, and 26 quarters (or 6.5 years) in the noninjury group. At 44 quarters, or 11 years, the probability of survival dropped to 40.3% for seriously injured older adults, 52.6% for older adults with minor injury, and 55.9% for noninjured older adults.

After adjusting for sex, education, race/ethnicity, and age, injured older adults continued to have significantly higher risks of death compared with the noninjured group (Table 3, column 4, hazard ratio = 1.213 for minor injury and hazard ratio = 1.711 for serious injury). Seriously injured older adults also had a higher risk of death than seniors with minor injuries at baseline (hazard ratio = 1.410, not shown). In addition, mortality risk increased with age and decreased with level of education. Females had a lower risk of death. Compared with non-Hispanic whites,

Table 2. Characteristics of the Linked NHIS-NDI Sample, 2001–2009: Adults Age 65+ by Injury Status at the Time of the NHIS Interview

	All		No Injury		Minor Injury		Serious Injury	
	%	95% CI	%	95% CI	%	95% CI	%	95% CI
Death	25.2	(24.8, 25.6)	24.9	(24.5, 25.4)	27.9	(24.9, 31.2)	38.4	(35.4, 41.6)
Age (mean)	74.4	(74.3, 74.5)	74.4	(74.3, 74.4)	75.2	(74.7, 75.8)	76.5	(76.1, 77.0)
65–69	29.3	(28.8, 29.8)	29.5	(29.0, 30.0)	27.6	(24.1, 31.3)	20.4	(17.9, 23.1)
70–74	23.8	(23.5, 24.2)	23.9	(23.6, 24.3)	20.9	(18.0, 24.2)	19.8	(17.4, 22.3)
75–79	20.8	(20.5, 21.2)	20.8	(20.5, 21.2)	20.0	(17.1, 23.3)	20.3	(18.0, 23.0)
80–84	15.1	(14.7, 15.4)	15.0	(14.7, 15.3)	13.8	(11.7, 16.3)	19.5	(17.2, 22.1)
≥85	11.0	(10.7, 11.3)	10.8	(10.5, 11.1)	17.7	(14.9, 20.9)	20.0	(17.5, 22.8)
Female	57.1	(56.7, 57.4)	56.9	(56.5, 57.2)	63.8	(60.2, 67.2)	66.5	(63.4, 69.5)
Race/ethnicity								
White	81.9	(81.4, 82.5)	81.8	(81.2, 82.4)	89.5	(87.2, 91.4)	85.9	(83.7, 87.9)
Black	8.1	(7.7, 8.5)	8.2	(7.8, 8.6)	3.6	(2.5, 5.1)	6.2	(4.9, 7.8)
Other	10.0	(9.5, 10.4)	10.0	(9.6, 10.4)	7.0	(5.4, 9.0)	7.9	(6.3, 9.7)
Education								
Less than HS	24.4	(23.9, 24.9)	24.4	(23.9, 25.0)	19.9	(17.0, 23.1)	26.6	(23.9, 29.4)
HS grad	36.5	(36.0, 37.0)	36.6	(36.1, 37.0)	33.6	(30.0, 37.3)	33.4	(30.5, 36.4)
Some college	20.6	(20.2, 21.0)	20.5	(20.1, 20.9)	23.7	(20.5, 27.3)	23.9	(21.1, 26.9)
College grad	18.6	(18.1, 19.1)	18.6	(18.0, 19.1)	22.8	(19.7, 26.3)	16.2	(13.9, 18.7)
Unweighted *N*	79,504		77,552		794		1,158	

Table 3. Models Predicting at Least 1 Night in the Hospital, Number of Nights in the Hospital, Subsequent Injury, and Later Mortality: Adults Age 65+ at the Time of the NHIS

	Subsequent injury	Any nights in hospital	Number of nights in hospital	Later mortality
	Coefficient (*SE*)	Coefficient (*SE*)	Coefficient (*SE*)	Coefficient (*SE*)
No injury (ref.)	—	—	—	—
Serious injury	0.691 (0.155)***	0.611 (0.156)***	0.049 (0.121)	0.537 (0.055)***
Minor injury	0.463 (0.185)*	0.359 (0.208)	0.125 (0.182)	0.193 (0.071)**
Female	0.243 (0.044)***	−0.093 (0.043)*	−0.076 (0.051)	−0.429 (0.015)***
Age 65–69 (ref.)	—	—	—	—
Age 70–74	0.015 (0.056)	0.169 (0.056)**	0.045 (0.082)	0.407 (0.026)***
Age 75–79	0.131 (0.060)*	0.403 (0.059)***	0.088 (0.070)	0.858 (0.025)***
Age 80–84	0.258 (0.065)***	0.640 (0.064)***	0.265 (0.098)**	1.326 (0.025)***
Age 85+	0.442 (0.084)***	0.733 (0.076)***	0.116 (0.088)	1.911 (0.026)***
Less than HS (ref.)	—	—	—	—
HS grad	−0.012 (0.062)	−0.264 (0.056)***	−0.091 (0.067)	−0.230 (0.019)***
Some college	0.113 (0.069)	−0.251 (0.062)***	−0.218 (0.076)**	−0.312 (0.022)***
College grad	0.134 (0.072)	−0.464 (0.064)***	−0.316 (0.079)***	−0.515 (0.025)***
White (ref.)	—	—	—	—
Black	−0.503 (0.066)***	0.049 (0.054)	0.377 (0.082)***	0.067 (0.025)**
Other	−0.491 (0.067)***	−0.405 (0.059)***	−0.023 (0.080)	−0.336 (0.026)***
Unweighted *N*	16,109	16,109	16,109	79,504

Note: Results in models 1–3 are estimated using the linked NHIS-MEPS sample and results in model 4 are estimated using the linked NHIS-NDI sample. Results in models 2 and 3 are from a two-part model with a logit model in the first part (model 2: any nights in hospital) and a generalized linear model (GLM) with a log link and gamma distribution for the second part (model 3: number of nights in hospital).
*$p < .05$, **$p < .01$, ***$p < .001$.

Table 4. Predicted Number of Nights in the Hospital: Adults Age 65+ at the time of the NHIS, Derived from Two-Part Model

	Number of nights in hospital	95% CI
No injury (ref.)	—	—
Serious injury	1.511**	(0.518, 2.503)
Minor injury	1.206	(−0.193, 2.605)
Female	−0.457*	(−0.838, −0.077)
Age 65–69 (ref.)	—	—
Age 70–74	0.521	(−0.075, 1.117)
Age 75–79	1.183***	(0.658, 1.707)
Age 80–84	2.291***	(1.534, 3.049)
Age 85+	2.002***	(1.344, 2.659)
Less than HS (ref.)	—	—
HS grad	−0.884***	(−1.373, −0.396)
Some college	−1.278***	(−1.832, −0.723)
College grad	−2.071***	(−2.648, −1.494)
White (ref.)	—	—
Black	1.358***	(0.784, 1.931)
Other	−0.968**	(−1.566, −0.370)

Note: Although serious injury has no effect on the length of hospital stays relative to no injury at baseline, it nearly doubled the odds of being hospitalized. The average marginal effect of 1.511 nights for those who had serious injury at baseline relative to individuals with no injury was calculated based on both parts of the two-part model: the added risk of any hospitalization multiplied by the average hospital nights among the hospitalized.
$^{*}p < .05$, $^{**}p < .01$, $^{***}p < .001$.

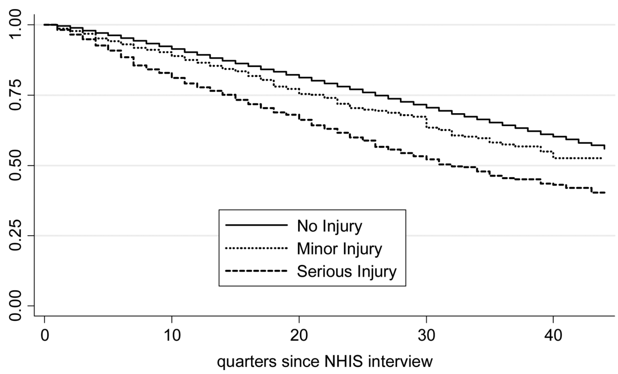

Figure 1. Comparative Kaplan–Meier survival curves for adults aged 65 and older. NHIS, National Health Interview Survey.

non-Hispanic blacks experienced higher mortality risks, and other race/ethnicity identity was associated with a lower risk of mortality.

Discussion

Using the nationally representative NHIS linked to the longitudinal MEPS and NDI, this study examined the long-term morbidity and mortality consequences of nonfatal injury. The current study adds to the small body of work that extends research focused on fall-related injuries among older adults to examine the long-term consequences of seniors injured from all causes. We considered the long-term consequences of both minor and serious injury, and included the risks of additional injury and hospitalization as key outcomes. We also included a longer period of mortality follow-up than had previously been considered, examining the risk of death up to 11 years after the initial interview.

This study found that all-cause nonfatal serious injury was significantly associated with each of the morbidity and mortality consequences considered. Relative to seniors with no reported injury at baseline, serious injury nearly doubled the risk of experiencing another injury and increased the predicted number of nights spent in the hospital by approximately 1.5 nights within 2.5 years after the initial injury. Negative consequences of nonfatal injury were not limited to serious injury. This analysis also showed that, when compared with no injury at baseline, minor all-cause nonfatal injuries were associated with a significant increase in risk of another medically attended injury. Similar to studies finding that one of the most important predictors of falls was a previous fall (Asada et al., 1996; Bergland & Wyller, 2004; Tromp et al., 2001; Yamashita, Noe, & Bailer, 2012), we found that injury—regardless of severity—was significantly associated with a heightened risk of subsequent injury. This finding lends support to the hypothesis that an initial injury may be the beginning of a cumulative process of declining health and functional capacity. Both serious and minor injuries were also significantly associated with increased mortality risk in the 11-year follow-up period. Our results are consistent with previous research that investigated the 4-year mortality risk associated with minor and serious injury (Porell & Carter, 2012), although their estimated hazard ratios of mortality were much larger than the ones estimated in our study.

This study has several limitations. First, the measurement of nonfatal injury in this study was likely to lead to underreporting of injury for three reasons: it needed to be serious enough to seek medical treatment, the measure asked retrospectively about past events (and was therefore subject to recall bias), and it was reported by a single respondent who may not have been aware of injuries sustained by other family members. Second, institutionalized persons were not included in the NHIS sampling frame. Our estimates of the associations between injury and long-term morbidity and mortality are conservative since institutionalized older adults sustain a disproportionately high number of injuries (Rubenstein, 2006) and are sicker and more medically complex than those living in the community (Wysocki et al., 2014).

Despite the exclusion of institutionalized persons from the NHIS interview, the MEPS sampling frame retained individuals institutionalized after the NHIS interview as long as they had a family member who could respond to the survey. Additionally, persons institutionalized after the NHIS interview were included in the linked NHIS-NDI data. We also retained persons who contributed information on all analysis variables in at least one MEPS interview, but who died, were institutionalized (without a family member to report), or left the United States during the MEPS panel. Third, unobserved characteristics, such as decreased physical functioning prior to injury, may bias our results by erroneously attributing the negative consequences of prior health declines to injury. We attempted to address this possibility by testing the sensitivity of our models to the addition of general health status, and found similar results. However, we acknowledge our study's results would not be as accurate as estimates from a prospective case-crossover design, such as the one employed by Finkelstein and colleagues (2005), that would control for pre-injury health status. The NHIS does not collect information on pre-injury health status for persons who sustained an injury, so we are restricted to the less-accurate study design of controlling for characteristics observed after the exposure of interest (in our case, nonfatal injury). Future research is needed to fully test the causal ordering of hypothesized mechanisms linking nonfatal injures with long-term consequences through reductions in health status and/or functional capacity with decreased resiliency to additional health insults.

Injuries have emerged as a pressing public health concern because they are now widely acknowledged to be preventable (Holder et al., 2001). Because even minor injuries are strongly associated with increased risks of later injury and mortality, preventing injury among older adults may be an effective way to improve quality of life and reduce declines in functional capacity. Successful injury prevention efforts include programs to encourage exercise to maintain and increase strength and balance, home modification, and supportive activities following other health events that could predispose individuals to injury such as psychotropic medication withdrawal, hip surgery, and cataract surgery (Stevens & Burns, 2015). Although these interventions have been recognized as effective in preventing fall-related injuries, the leading single cause of nonfatal injury among older adults, further research is necessary to examine whether these interventions would also be successful when applied to other top causes of nonfatal injury: overexertion, being struck by an object or person, and transportation-related injuries (Xu & Drew, 2016). Interventions with the most promise to successfully prevent nonfall-related injury focus on preventing hospital readmissions by addressing the need for assistance with ADLs among recently discharged older adults (DePalma et al., 2013) and the coordination of prevention support and efforts across multiple clinical and community-based stakeholders involved with care and service provision to older adults (Casey et al., 2016). If we fail to reduce injury incidence, we will likely see the injury-related costs among older adults increase because of the large projected increases in the size of the elderly population (Jacobsen, Kent, Lee, & Mather, 2011). Focusing our efforts on reducing nonfatal injury among older adults and its associated increase in healthcare spending will pay large dividends as the share of the population aged 65 and older grows.

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