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# Self-reported Hearing Difficulty and Risk of Accidental Injury in US Adults, 2007 to 2015

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**IMPORTANCE** Accidental injuries are a leading cause of morbidity and mortality in the United States. Hearing problems may be associated with an increased risk for such injuries.

**OBJECTIVE** To investigate associations between hearing difficulty and risk of accidental injuries among US adults.

**DESIGN, SETTING, AND PARTICIPANTS** Cross-sectional analysis of responses of a nationally representative sample of 232.2 million individuals 18 years or older who participated in the National Health Interview Survey from 2007 to 2015 and responded to the questions related to the hearing and injury modules.

**MAIN OUTCOMES AND MEASURES** The main outcome variable was accidental injury in the preceding 3 months. Hearing status was self-reported as "excellent," "good," "a little trouble," "moderate trouble," "a lot of trouble," and "deaf." Prevalence of accidental injuries was analyzed based on demographic characteristics and hearing status. Odds ratios (ORs) and 95% CIs for injuries adjusted for demographics were calculated for degrees of hearing difficulty. A secondary outcome was association of hearing status with type of injury and was classified as driving related, work related, or leisure/sport related.

**RESULTS** Of 232.2 million US adults, 120.2 million (51.7%) were female, and 116.3 million (50.1%) considered their hearing to be less than excellent. Accidental injuries occurred in 2.8% of survey respondents. In comparison with normal-hearing adults (those with self-rated excellent or good hearing), the odds of accidental injury were higher in those with a little trouble hearing (4.1%; OR, 1.6; 95% CI, 1.5-1.8), moderate trouble hearing (4.2%; OR, 1.7; 95% CI, 1.4-1.9), and a lot of trouble hearing (4.8%; OR, 1.9; 95% CI, 1.6-2.3). Work- and leisure-related injuries were more prevalent among those with self-perceived hearing difficulty. Multivariate analysis, adjusted for age and sex, revealed leisure-related injuries was most consistently associated with various degrees of hearing difficulty. Odds ratios were 1.2 (95% CI, 1.0-1.4) in those with a little trouble hearing, 1.4 (95% CI, 1.1-1.9) in those with moderate trouble hearing, and 1.5 (95% CI, 1.1-2.2) in those with a lot of trouble hearing.

**CONCLUSIONS AND RELEVANCE** Hearing difficulty is significantly associated with accidental injury, especially injury related to work or leisure. Increased awareness about hearing difficulty and its proper screening and management may assist in decreasing accidental injury.

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Accidental injuries are among the leading causes of morbidity and mortality in the United States.<sup>1</sup> According to the National Health Report by the Centers for Disease Control and Prevention (CDC), unintentional injuries comprised 5.0% of all recorded causes of death in 2011.<sup>1</sup> The number of emergency department visits for unintentional injuries was an estimated 28.1 million in 2013.<sup>2</sup> Various factors have been identified to increase the risk of accidental injuries, including chronic health conditions and sensory impairments.<sup>3,4</sup> As life expectancy increases with advances in health care technology and delivery, more individuals now live with chronic health problems<sup>5</sup> and sensory impairments,<sup>6</sup> and these rates are expected to continue to increase.<sup>7,8</sup> Hearing loss is one of the most common sensory impairments and is estimated to affect 16% of the US population.<sup>9</sup>

The association between accidental injury and hearing loss has been the subject of a number of previous investigations. A study of South Carolina Medicaid billing data for 2002 and 2003 revealed that children with hearing loss were twice as likely to be treated for injuries in the hospital or emergency department than those without hearing loss.<sup>10</sup> Another report using data from the National Health Interview Survey (NHIS) from 1985 to 1994 found occupational injuries to be 1.5 times as likely to occur in adults with hearing impairment and twice as likely to occur in adults with deafness.<sup>11</sup> Other studies assessing the risk of accidental injury with respect to hearing status have revealed no statistically significant difference.<sup>4,12</sup> Most studies in the literature have been local or single-institution reports with small sample sizes or have focused on certain patient populations or categories of accidental injury.<sup>3</sup>

In the present study, we used a nationally representative data set to investigate the association between hearing difficulty and accidental injury. Furthermore, we sought to explore the correlation of hearing difficulty with different types of accidental injuries during work, driving, and leisure and to use a nationwide data set to generate national estimates for the prevalence of hearing difficulty and risk of accidental injury.

## Methods

The NHIS data set was used as the data source. These surveys included responses to various health-related questions from a clustered, nationally representative sample of individuals from across the United States. Results from the most recent surveys from 2007 to 2015 were obtained and merged. Detailed information regarding the surveys and their procedures and definitions is available on the CDC website.<sup>13</sup> A data use agreement was signed before obtaining the data, and the Partners Committee on Clinical Investigation deemed that exempt status applied to this study owing to the use of publicly available, deidentified data.

Noninstitutionalized individuals 10 years or older composed the interviewee pool. Persons 18 years or older who had responded to the questions related to the hearing and injury modules were included in this study. The main independent

## Key Points

**Question** Is hearing difficulty associated with risk of accidental injuries?

**Findings** This cross-sectional analysis of National Health Interview Survey data found that, of the 6.6 million US adults who experienced accidental injuries annually between 2007 and 2015, approximately 1 in 6 considered their hearing to be less than "excellent" or "good." Risk of accidental injuries increased with degree of self-perceived hearing difficulty, with those with "a lot of trouble" hearing being twice as likely to have incurred an accidental injury.

**Meaning** Hearing difficulty is associated with an increased risk of accidental injuries.

variables were age, sex, and self-perceived hearing status. Hearing status was classified as "excellent," "good," "a little trouble hearing," "moderate trouble hearing," "a lot of trouble hearing," and "deaf." The main outcome variable was occurrence of any accidental injury within the preceding 3 months. Type of injury was further classified as driving related, work related, or leisure/sport related. The data were imported into and analyzed with SPSS software, version 24.0 (SPSS Inc).

National estimates were extrapolated using the reported weights, clustering, and strata data, which accounted for the complex clustered design of the surveys (SPSS Complex Samples Algorithms CSTABULATE, with  $\chi^2$  for significance testing and CSLOGISTIC for logistic regression). The prevalence of accidental injuries and respective 95% CIs were calculated and analyzed based on the respondents' age, sex, marital status, educational level (elementary school, high school, or  $\geq$ college), ethnicity (Hispanic or non-Hispanic), race (black or nonblack), and hearing status. Adjusted odds ratios (ORs) and 95% CIs were calculated for injuries based on degree of hearing difficulty after adjusting for the above demographic variables. Two-sided  $P < .05$  was considered statistically significant.

## Results

On average, 272 402 adults were surveyed annually, which extrapolated to 232.2 million adults (95% CI, 228.8 million to 235.7 million) annually, with 120.2 million (51.7%) female. **Table 1** summarizes the demographic and injury characteristics of the study population. Approximately 116.3 million respondents (95% CI, 114.3 million to 118.3 million) (50.1%; 95% CI, 49.7-50.5) considered their hearing to be less than excellent, and 36.5 million (95% CI, 35.7 million to 37.3 million) (15.7%; 95% CI, 15.5-16.0) considered their hearing to be less than good. Accidental injuries in the preceding 3 months were reported by 6.6 million respondents (95% CI, 6.4 million to 6.8 million) (2.8%; 95% CI, 2.8%-2.9%).

The details of respondents' hearing status along with the prevalence of accidental injuries based on this hearing status are provided in **Table 2**. There were no differences in the rate of injuries between male and female respondents (2.8% vs 2.8%), but the mean age in those who reported

accidental injuries (48.0 years; 95% CI, 47.5-48.6) was significantly higher than in those who did not (46.4 years; 95% CI, 46.2-46.6).

The Figure depicts the prevalence of different types of injuries based on hearing status. In these univariate analyses, rate of driving-related injuries did not statistically differ based on hearing status, but the rate of leisure-related injuries steadily increased from 0.8% (95% CI, 0.8%-0.9%) in those with excellent hearing to 1.4% (95% CI, 0.6%-3.2%) in those who considered themselves deaf. The rate of work-related injuries was higher in those with good hearing or a little trouble hearing than in those with excellent hearing or more severe forms of self-identified hearing difficulty.

Table 3 presents the results of multivariate analysis of the odds of sustaining injuries based on hearing status after adjustment for age and sex. When compared with those with excellent hearing, incurrence of an accidental injury was significantly associated with having a little trouble hearing (OR, 1.6; 95% CI, 1.5-1.8), moderate trouble hearing (OR, 1.7; 95% CI, 1.4-1.9), and a lot of trouble hearing (OR, 1.9; 95% CI, 1.6-2.3). Leisure-related injuries were most consistently associated with various degrees of hearing difficulty, and ORs steadily increased from 1.2 (95% CI, 1.0-1.4) in those with a little trouble hearing to 1.4 (95% CI, 1.1-1.9) in those with moderate trouble hearing and 1.5 (95% CI, 1.1-2.2) in those with a lot of trouble hearing.

## Discussion

Accidental injuries impose a significant health care and economic burden in the United States<sup>14</sup> and globally.<sup>14,15</sup> According to an analysis conducted by the CDC on injury data from the National Electronic Injury Surveillance System, the estimated lifetime costs of medical treatments and loss of wages for accidental injuries in 2013 were \$253.5 billion, whereas the mean cost per injured person was more than \$14 000.<sup>14</sup> Of these expenditures, 37% were associated with injuries from falls and 21% from transportation-related injuries. Although many risk factors for accidental injury have been reported in the literature,<sup>3,16</sup> the association between these injuries and certain sensory impairments, such as hearing loss, are not well understood. The near-universal availability of screening and treatment options for mild to profound hearing loss would classify hearing loss as a preventable risk factor for accidental injuries.

In the present study, hearing difficulty was reported by approximately 15.7% of the adults, and accidental injuries had occurred in 2.8% regardless of hearing status. The rate of accidental injury steadily increased from 2.4% in those with excellent hearing to 4.8% in those with a lot of trouble hearing. This rate was lower in the persons who considered themselves to be deaf (2.8%) but higher than in those with excellent hearing. When the injuries were stratified based on type, a similar trend was noted in work-related injuries; those with good hearing or a little trouble hearing had higher rates (0.5% and 0.6%, respectively) of injury at work compared with respondents in other hearing categories,

**Table 1. Demographic Characteristics and Distribution of Self-perceived Hearing Status and Accidental Injury Types Among NHIS Respondents, 2007-2015**

Characteristic	Total	
	No. (95% CI) <sup>a</sup>	% (95% CI)
Mean age, y	46.4	
Sex		
Male	112.2 (110.2-113.9)	48.3 (48.0-48.5)
Female	120.2 (118.3-122.0)	51.7 (51.5-52.0)
Hearing status		
Excellent	116.0 (114.0-117.9)	49.9 (49.5-50.3)
Good	79.8 (78.4-81.2)	34.4 (34.1-34.7)
A little trouble	23.0 (22.5-23.6)	9.9 (9.7-10.1)
Moderate trouble	8.5 (8.2-8.7)	3.6 (3.5-3.7)
A lot of trouble	4.4 (4.3-4.5)	1.9 (1.8-2.0)
Deaf	0.5 (0.4-0.6)	0.2 (0.2-0.3)
Marital status		
Single	106.7 (104.8-108.6)	46.0 (45.5-46.5)
Married	125.1 (122.8-127.4)	54.0 (53.5-54.5)
Educational level		
Elementary school	11.6 (11.2-12.0)	5.0 (4.8-5.2)
High school	83.1 (81.6-84.7)	36.0 (35.5-36.5)
≥College	136.2 (133.7-138.7)	59.0 (58.5-59.5)
Ethnicity		
Hispanic	33.5 (32.4-34.6)	14.4 (14.0-14.9)
Non-Hispanic	198.7 (195.5-202.0)	85.6 (85.1-86.0)
Race		
Black	28.6 (27.6-29.6)	12.3 (11.9-12.7)
Other <sup>b</sup>	203.7 (200.3-207.0)	87.7 (87.3-88.1)
Accidental injury type		
Driving related	0.5 (0.5-0.6)	0.2 (0.2-0.3)
Work related	1.1 (1.0-1.1)	0.5 (0.4-0.5)
Leisure related	2.0 (1.9-2.1)	0.8 (0.8-0.9)

Abbreviation: NHIS, National Health Information Survey.

<sup>a</sup> Number in millions.

<sup>b</sup> Other includes white, Native American, Pacific Islander, multiracial, and race unspecified.

including deaf respondents (0.3%). One possible explanation for lower rates of injury among individuals who consider themselves deaf is that they may not engage in certain home- or work-related activities or tasks that could increase their risk of injury.

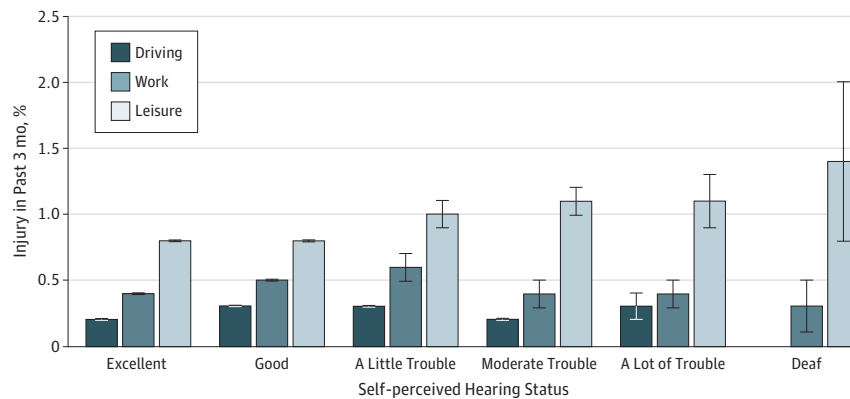
In contrast, there was a steady increase in leisure-related injuries as the degree of hearing difficulty worsened, from 0.8% in persons with excellent hearing to 1.4% in the deaf adults. This finding indicates that hearing-impaired or deaf individuals are at greater risk for sustaining injuries during sports or leisure activities in contrast to work-related injuries. Multivariate analysis further confirmed the association between work- and leisure-related injuries and the levels of hearing difficulty discussed above. However, the OR for the deaf category did not reach statistical significance in the multivariate analysis, which may be related to the lower number of interviewees after adjustment for age and sex. Driving-related

Table 2. Prevalence of Any Accidental Injuries Based on Self-perceived Hearing Status

Hearing Status	Any Injuries <sup>a</sup>			
	Yes		No	
	No. (95% CI)	% (95% CI)	No. (95% CI)	% (95% CI)
Excellent	2.8 (2.7-2.9)	2.4 (2.3-2.5)	113.2 (111.2-115.1)	97.6 (97.5-97.7)
Good	2.3 (2.2-2.4)	2.9 (2.7-3.0)	77.5 (76.2-78.9)	97.1 (97.0-97.3)
A little trouble	0.9 (0.9-1.0)	4.1 (3.8-4.4)	22.1 (21.5-22.6)	95.9 (95.6-96.2)
Moderate trouble	0.4 (0.3-0.4)	4.2 (3.7-4.7)	8.1 (7.9-8.4)	95.8 (95.3-96.3)
A lot of trouble	0.2 (0.2-0.2)	4.8 (4.1-5.6)	4.2 (4.1-4.4)	95.2 (94.4-95.9)
Deaf	<0.1 (<0.1)	2.8 (1.7-4.9)	0.5 (0.5-0.6)	97.2 (95.1-98.3)

<sup>a</sup> Number in millions.

Figure. Prevalence of Accidental Injuries in the Previous 3 Months by Hearing Status and Type of Injury



Driving,  $P = .07$ ; work,  $P = .03$ ; and leisure,  $P = .01$ .  $P$  values are the outputs of SPSS Complex Samples Algorithms CSTABULATE, with  $\chi^2$  for significance (SPSS Inc). The deaf category was excluded for driving-related injury because of sample size limitations in the number of deaf drivers. Error bars indicate 95% CIs.

Table 3. Odds of Sustaining Accidental Injuries Based on Self-perceived Hearing Status Adjusted for Age, Sex, Marital Status, Educational Level, Ethnicity, and Race

Hearing Status	OR (95% CI)			
	Any Injuries	Driving Related	Work Related	Leisure Related
Excellent	1 [Reference]	1 [Reference]	1 [Reference]	1 [Reference]
Good	1.2 (1.1-1.3)	1.4 (1.1-1.7)	1.3 (1.1-1.5)	1.0 (0.8-1.1)
A little trouble	1.6 (1.5-1.8)	1.8 (1.3-2.5)	1.9 (1.4-2.5)	1.2 (1.0-1.4)
Moderate trouble	1.7 (1.4-1.9)	1.1 (0.6-1.8)	1.4 (0.9-2.0)	1.4 (1.1-1.9)
A lot of trouble	1.9 (1.6-2.3)	2.4 (1.3-4.5)	1.4 (0.7-2.8)	1.5 (1.1-2.2)
Deaf	1.1 (0.6-2.0)	NA <sup>a</sup>	1.0 (0.3-3.5)	1.9 (0.8-4.5)

Abbreviations: NA, not applicable; OR, odds ratio.

<sup>a</sup> The deaf category was excluded for driving-related injury because of sample size limitations in the number of deaf drivers.

injuries, when adjusted for age and sex, also had a significant association with good hearing, a little trouble hearing, and a lot of trouble hearing.

A systematic review of chronic health problems and risk of accidental workplace injuries in 2008 identified a positive association for hearing impairment, neurotic illness, diabetes, epilepsy, and use of sedating medication with injuries.<sup>3</sup> The hearing portion of this review included 15 studies. Five of these studies defined *hearing loss* according to either pure-tone audiometry or a physician's determination, whereas the remaining studies relied on participants' self-determination. Overall, the review concluded that, in most comparisons, the ORs of work-related injuries were greater than 1.5 with any type of hearing loss. A study of hearing loss and agricultural injuries in Iowa revealed that persons with self-reported hearing loss were twice as likely to sustain injuries.<sup>17</sup> When pure-tone thresholds were considered, a pure-tone average greater than 25 dB (hearing level) in the better ear was associated with an

OR of 1.6. Exposure to noise at work increased ORs for those with self-reported hearing loss and a pure-tone average greater than 25 dB in the more affected ear. In another study in an elderly Turkish population, those with hearing problems were 1.3 times more likely to have experienced at-home accidents.<sup>18</sup> Overall, the trends in these studies appear consistent with the findings of the present investigation.

**Limitations**

There are several limitations to this study. Survey-based studies are generally dependent on the accuracy of the data collection process and respondents' recall bias. However, the CDC maintains high standards for conduction and collection of the NHIS, and these surveys have been used in previous studies.<sup>19,20</sup> The subjective nature of the hearing status in the surveys is another limitation. Hearing loss is typically defined based on pure-tone thresholds, which would provide a more objective, perhaps more accurate assessment of an individual's hearing status.

However, self-reported hearing difficulty may be more indicative of an individual's functional hearing ability in daily life. Notably, in an assessment of the association of agricultural injuries with hearing loss, Choi et al<sup>17</sup> found that self-reported hearing status was a stronger predictor of injury than pure-tone audiometry. In other studies, including a study of the NHIS 1985 to 1994 databases by Zwerling et al<sup>11</sup> and a study of farm injuries in New York farmers by Hwang et al,<sup>21</sup> a positive association between self-reported hearing difficulty and accidental injuries was identified.

Despite these limitations, our analysis of the NHIS data enabled us to characterize the association between hearing difficulty and accidental injuries and to produce national estimates using a representative sample. These surveys help investigators understand health care problems and their burden from the perspective of patients. Future studies should further investigate the observed trends in the present study and expand on

the current knowledge. Increased awareness about hearing difficulty and its appropriate screening and management may help decrease the risks and burden of accidental injuries in the community. Otolaryngologists and audiologists can play a central role in educating the public and in facilitating the development of local, state, and federal strategies and policies.

## Conclusions

An increased rate of accidental injury was strongly associated with self-reported poorer hearing quality in US adults. When stratified based on injury type, leisure-related injuries were most consistently associated with the degree of self-perceived hearing difficulty. Those with good hearing or a little trouble hearing had higher odds of sustaining work-related injuries.

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**Study concept and design:** Bhattacharyya.

**Acquisition, analysis, or interpretation of data:** All authors.

**Drafting of the manuscript:** Mahboubi, Bhattacharyya.

**Critical revision of the manuscript for important intellectual content:** All authors.

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**Administrative, technical, or material support:** Lin, Mahboubi.

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