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Sex Differences in Mortality Following Isolated Traumatic Brain Injury among Older Adults

Jennifer S. Albrecht, PhD[1], **Maureen McCunn, MD**[2], **Deborah M. Stein, MD, MPH**[3], **Linda Simoni-Wastila, PhD**[4], and **Gordon S. Smith, MB, ChB, MPH**[1,5]

Maureen McCunn: mmccunn@anes.umm.edu; Deborah M. Stein: dstein@umm.edu; Linda Simoni-Wastila: lsimoniw@rx.umaryland.edu; Gordon S. Smith: gssmith@som.umaryland.edu

[1]Department of Epidemiology and Public Health, University of Maryland School of Medicine [2]Department of Anesthesiology, Divisions of Trauma Anesthesiology and Surgical Critical Care, R Adams Cowley Shock Trauma Center, University of Maryland School of Medicine [3]Department of Surgery, Division of Surgical Critical Care, R Adams Cowley Shock Trauma Center, University of Maryland Medical Center [4]Department of Pharmaceutical Health Services Research, University of Maryland School of Pharmacy [5]Shock, Trauma and Anesthesiology Research (STAR) – Organized Research Center, National Study Center for Trauma and Emergency Medical Services, University of Maryland

Abstract

Background—Older adults have the highest rates of hospitalization and mortality from traumatic brain injury (TBI), yet outcomes in this population are not well studied. In particular, contradictory reports on the protective effect of female sex on mortality following TBI may have been related to age differences in TBI and other injury severity and mechanism. The objective of this study was to determine if there are sex differences in mortality following isolated TBI among older adults and compare to findings using all TBI. A secondary objective was to characterize TBI severity and mechanism by sex in this population.

Methods—This was a retrospective cohort study conducted among adults aged 65 and older treated for TBI at a single large level I trauma center 1996–2012 (n=4,854). Individuals treated for TBI were identified using International Classification of Disease (ICD-9-CM) codes. Isolated TBI was defined as an Abbreviated Injury Scale score = 0 for other body regions. Our primary outcome was mortality at discharge.

Results—Among those with isolated TBI (n=1,320), women (45% of sample) were older (78.9 (standard deviation 7.7) years) than men (76.8 (7.5) years)($p<0.001$). Women were more likely to have been injured in a fall (91% vs. 84%, $p<0.001$). Adjusting for multiple injury severity

Corresponding Author: Jennifer S. Albrecht, University of Maryland School of Medicine, 10 South Pine Street, MSTF 334C, Baltimore, MD 21201, telephone: (410) 706-0071, fax: (410) 706-0098, jalbrecht@epi.umaryland.edu.

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Conflict of Interest

For the remaining authors, no conflicts were declared.

measures, female sex was not significantly associated with decreased odds of mortality following isolated TBI (OR 1.01; 95% CI 0.66, 1.54). Using all TBI cases, adjusted analysis found that female sex was significantly associated with decreased odd of mortality (OR 0.73; 95% CI 0.59, 0.89).

Conclusions—We found no sex differences in mortality following isolated TBI among older adults, in contrast with other studies and our own analyses using all TBI cases. Researchers should consider isolated TBI in outcome studies to prevent residual confounding by severity of other injuries.

Level of Evidence—Epidemiologic study, level III.

Keywords

Traumatic brain injury; mortality; sex differences

Background

Older adults have the highest rates of hospitalization and mortality following TBI and experience poorer outcomes compared to younger adults with the same injury severity.[1–4] Older adults differ from younger adults in risk factors, mechanisms, and outcomes of TBI, yet the majority of research on TBI to date has focused primarily on younger adults.[1–4]

Animal studies have suggested that female hormones may be protective against mortality following traumatic brain injury, but clinical studies have reported contradictory results.[5–13] Three small human trials provided evidence that progesterone decreased mortality following TBI,[14–16] yet these results were not confirmed in two large randomized controlled trials that examined the clinical effectiveness of progesterone for the treatment of TBI.[17,18]

Age and sex differences in injury severity and mechanism could explain these conflicting results. In older adults, injury mechanisms differ from those of younger adults and differences in serum levels of female sex hormones are minimized.[19–21] Injury to other body regions is even more relevant to mortality outcomes among the elderly as it is well known that they have higher in-hospital mortality rates even for more minor injuries. However, even the few prior studies that focused on isolated TBI also included minor injury to other body regions that could have been associated with sex and impacted mortality.[7,11,12] Furthermore, prior retrospective analyses of sex differences in mortality used trauma data bases comprised of individuals treated at multiple locations, across which there may be important variations in care.[6–12] We propose to address gaps in the prior literature by assessing sex differences in mortality following isolated TBI among adults aged 65 and older treated at a single level 1 trauma center and compare with results including all TBI in the analysis. Differences in serum levels of sex hormones are minimized among adults aged 65 and older while our focus on isolated TBI will reduce confounding by severity of injury to other body regions. In addition our single-center setting reduces variation by treatment protocol. A secondary objective is to characterize TBI severity and mechanism in this population. We hypothesize that after controlling for injury severity and mechanism, there will be no sex differences in all cause in-hospital mortality following isolated TBI.

Methods

Study Design and Setting

This was a retrospective cohort study to assess the impact of female sex on mortality at discharge among adults aged 65 and older who were treated at the R Adams Cowley Shock Trauma Center (STC) of the University of Maryland Medical Center for TBI during 1996–2012. The STC is a Level 1 trauma center that treats more than 8,000 patients annually including 33% of all trauma cases in Maryland. It is the busiest civilian trauma program in the United States. Data for this study came from STC trauma registry (STR) which contains data on all STC admissions since 1996 and includes demographic and clinical information, mechanism of injury, details on the nature and severity of the injury, and procedures performed. The STC has a long tradition of standard treatment protocols for all trauma including TBI that follow accepted best practices.

Selection of Participants

All STC admissions during 1996–2012 aged 65 and older with a diagnosis of TBI (International Classification of Disease version 9, Clinical Modification (ICD-9-CM)) codes 800.xx, 801.xx, 803.xx, 804.xx, 850.xx- 854.1x, 950.1–950.3, 959.01) were eligible for this study. These ICD-9-CM codes represent the Center for Disease Control and Prevention's (CDC) case definition for TBI, which has been reported to have a sensitivity of 89% to detect severe TBI and a positive predictive value of 93%.[22–24] Our primary outcome was all cause in-hospital mortality at discharge from STC.

Measures

Injuries were coded in the STR using the Abbreviated Injury Score (AIS) system (1990) which is converted to ICD-9-CM codes using proprietary software, and injury mechanisms are coded using E codes. AIS is a method of ranking anatomic injury severity relative to its threat to life.[25] The AIS score ranges from 1–6, with 1 indicating a mild injury and 6 indicating a currently unsurvivable injury. We specified seven AIS body regions: head, neck, face, thorax, abdomen, upper extremities, and lower extremities. To be included in this study, individuals had to have an AIS head score >0 (neck injuries not included). Isolated TBI was defined as an AIS = 0 for all other body regions.

TBI Severity

The AIS head score is coded at hospital discharge using evidence from CT and MRI scans by a trained AIS coder and provides an accurate description of TBI injury severity. All injuries to the head were coded; therefore an individual could have received more than one AIS code, but anatomic TBI severity was determined using the highest AIS head score.

The Glasgow Coma Scale (GCS) measures neurologic deficit in eye opening, verbal, and motor response. [26–28] It is commonly used as an initial measure of TBI severity because of its ease of administration. Using the standard GCS categories, we categorized TBI as mild (GCS 14–15), moderate (9–13), and severe (<9).[26–28]

Injury Mechanism

ICD-9-CM E codes were used to define injury mechanism. We created a variable indicating any motor vehicle transport collision (MVC) (E810–E818), and specified by whether the injured was the driver, passenger, or pedestrian. We created a variable indicating any fall (E880–E888) and specified as on stairs, different level, same level, and unspecified. We also created a category for assaults.

Other Injuries Measures

The Injury Severity Score (ISS) is widely used to assign an overall severity score for patients with multiple injuries.[29] Major or polytrauma is defined as an ISS >15.[30] We created standard categories of ISS scores based on its distribution and the definition of major trauma: 0–9, 10–15, 16–25, 26–74, 75.

For descriptive purposes, we created indicator variables for any injury to the neck, face, thorax, abdomen, upper extremities, and lower extremities using the maximum AIS scores for each body region. An AIS score of ≥ 1 indicated injury. We also created an indicator variable measuring severity of injury to any another body region. We categorized this variable as no other injury (AIS score = 0), minor injury (AIS scores of 1–2), and moderate/severe injury (AIS scores ≥3).

Clinical Measures

Blood alcohol concentration (BAC) assays were routinely performed on STC admissions from 1997 onward (missing for 1996). Based on distribution, we categorized BAC as follows: negative test, <0.1 g/dL, and ≥ 0.1 g/dL. Admission systolic blood pressure (mm Hg) based on the American Heart Association guidelines (<90, 90 to <120, 120 to <140, 140 to <160, 160 to <180, ≥180).[31] Length of stay at STC was measured in days. For individuals with a length of stay less than 1 day who died, we created an ‘early death’ category. All other lengths of STC stay were categorized based on distribution as < 2 days, 2 – 6 days, 1 week – < 2 weeks, 2 weeks – < 4 weeks, and > 4 weeks.

Comorbid conditions were gathered from STC admission assessment data and coded using ICD-9 codes. From these, we created the following indicator variables: alcohol dependence, Alzheimer’s disease and related dementias, cardiac arrhythmia, chronic obstructive pulmonary disease (COPD), diabetes, depression, hypertension, heart failure, ischemic heart disease, neurologic disorders (includes Parkinson’s disease and epilepsy), and stroke. We created a variable indicating multi-morbidity. We summed indicator variables for chronic conditions and categorized individuals as having no, one, or more than one chronic condition.

Data Analysis

We compared the distributions of all variables by sex using chi-square test for categorical variables and Student’s t-test for age, and reported p-values in Tables 1 and 2. Similarly, we also examined the associations of all variables, including admission year as a means of controlling for changes in TBI care over time, with mortality at discharge from STC. We conducted all analyses for isolated TBI and all TBI.

Variables associated with sex and mortality in bivariate analysis were selected for the final regression model with a stepwise procedure ($p \leq 0.1$ for entry and $p \leq 0.05$ for retention in model). Because sex was our primary exposure, we forced it into the model. We modelled the GCS score as a categorical variable with values 3–15, but also used the three categories we created for bivariate analysis (GCS 14–15, 9–13, and <9). We grouped AIS head severity score '6' with '5' due to small cell sizes. We included AIS scores from each body region and grouped AIS scores > 3 as '4' due to small cell sizes for our analysis of all TBI. We modelled the log-odds of mortality at discharge from the STC using logistic regression.

We conducted sensitivity analyses to test whether our results were sensitive to inclusion and exclusion criteria. To test whether results were sensitive to our definition of isolated TBI, we restricted analyses to individuals with isolated severe TBI, defined as AIS >3. The potential protective effect of female sex on mortality is believed to act through the prevention of secondary injury; therefore, we conducted analyses excluding individuals who died within 12 and 24 hours of admission, all individuals with lengths of stay less than 12 or 24 hours, and individuals with admission SBP <90.[32]

Data analysis was performed using SAS version 9.3 (SAS Institute, Cary, NC) and a p-value of < 0.05 was considered statistically significant. This study was approved by the Institutional Review Board of the University of Maryland, Baltimore.

Results

Isolated TBI

There were 4,854 adults aged 65 and older admitted to the STC from 1996–2012 with TBI. Of these, 1,320 (27%) met criteria for isolated TBI. Women (n=590) comprised 45% of the sample.(Table 1) The average age among women with TBI was significantly older (78.9 (standard deviation 7.7) years) than among men (76.8 (7.5) years)($p<0.001$), and this was primarily due to a greater proportion of individuals aged over 85 years (25% among women vs. 18% among men, $p<0.001$). Women were more likely to have depression (8% vs 2%, $p=0.01$) and hypertension (59% vs. 53%, $p=0.03$) compared to men. Women were less likely to have alcohol dependence (2% vs. 6%, $p<0.001$) compared to men.

On admission, women were more likely than men to have a negative BAC (88% vs. 84%, $p=0.005$). There was no difference in mortality at discharge (16% women vs. 17% men, $p=0.78$). Women were less likely to have GCS scores <9 on admission (15% vs. 18%, $p=0.37$)) compared to men but this difference was not statistically significant (Table 2). Mean head AIS score did not differ between women and men (3.4 (sd 1.4) vs. 3.5 (sd 1.4), $p=0.19$).

Cause of injury differed by sex. Women were more likely to be injured in a fall (91% vs. 84%, $p<0.001$)) compared to men. If injured in a fall, women were more likely to fall on stairs (18% vs. 15%) compared to men. If injured in a motor vehicle collision, women were more likely to be passengers (31% vs. 11%).

In our unadjusted logistic regression model, female sex was not significantly associated with decreased odds of mortality at discharge from STC (OR 0.98; 95% CI 0.72, 1.32). Adjusting for sex, age, race, AIS head score, GCS, cardiac arrhythmia, admission systolic blood pressure, and an indicator variable for transport to STC directly from scene, female sex was not significantly associated with decreased odds of mortality at discharge from STC (OR 1.01; 95% CI 0.66, 1.54) (Table 3). This model had excellent discriminatory power (area under the receiver operating curve (AUROC) 0.92; 95% CI 0.90, 0.94) and there was no evidence of poor model fit (Hosmer-Lemeshow p = 0.47). Including the GCS as a categorical variable ranging from 3–15 did not change the effect estimate; hence, we reported the three category GCS for ease of interpretation.

All TBI

Individuals with injury to other body regions comprised 73% of our initial sample (n=4,854). Women were less likely to have GCS scores <9 (13% vs. 18%, p<0.001) compared to men (Appendix Table A1). Women were less likely to have additional injuries to the spine (17% vs. 20%, p<0.001) and thorax (21% vs. 26%, p<0.001), but were more likely to suffer injury to lower extremities (28% vs. 24%, p=0.003) compared to men. Falls were the top cause of injury and were more common among women (75% vs. 64%, p<0.001)(Appendix Table A2). Adjusting for sex, age, admission year, AIS head score, GCS, ISS, cardiac arrhythmia, admission systolic blood pressure, severity of other injuries, AIS face severity score, AIS spine severity score, AIS thorax severity score, AIS abdominal severity score, AIS upper extremity score, and an indicator variable for transport to STC directly from scene, female sex was significantly associated with decreased odds of mortality at discharge from STC (OR 0.73; 95% CI 0.59, 0.89)(Table 4). This model also had excellent discriminatory power (area under the receiver operating curve (AUROC) 0.91; 95% CI 0.90, 0.92) and there was no evidence of poor model fit (Hosmer-Lemeshow p = 0.12).

To test whether our results were sensitive to our TBI definition, we conducted an analysis among isolated TBI admissions with a head AIS >3, representing moderate to severe TBI. This group comprised 363 (42%) women and 494 (58%) men. The majority had GCS scores of 14–15 (61% of women and 61% of men, p=0.67)(results not shown). Falls were responsible for the greatest proportion of injuries (93% in women and 89% in men, p=0.19). Adjusting for all variables in our main model, female sex was not significantly associated with decreased odds of mortality at discharge from STC (OR 1.08; 95% CI 0.70, 1.68). Additional sensitivity analyses resulted in no significant change to the effect estimate whether conducted on isolated TBI or all TBI cases.

Discussion

In contrast to other studies and our own analyses using all TBI cases, when isolated TBI was examined we found no sex differences in mortality following TBI, providing support for our hypothesis.[6,7,10] Our analysis of older adults admitted to a level 1 trauma center for TBI over a 16 year period provides extensive characterization of injury severity and mechanism

among older adults by sex and suggests that older women have different injury mechanisms and may have less severe injury compared to men.

Most outcome studies on TBI, including those assessing sex differences in mortality, include cases with injuries to other body regions.[6–12] Few studies examine isolated TBI. In one retrospective study of individuals with isolated moderate to severe TBI treated at 17 trauma centers in Austria between 2001–2010, Leitgeb et al. (2011) also did not observe a significant effect of sex on mortality when controlling for injury severity and mechanism.[12] However, this study included individuals of any age and cases with AIS scores <3 for other body regions. In contrast, our study excluded individuals <65 years and those with any other injury (AIS scores >0 for any other body region). Most individuals in the Leitgeb study had severe TBI injury, reflected by an average GCS score of 5 compared with 13 for cases in our study.[12] This large difference in TBI severity could explain why inclusion of individuals with injury to other body regions in the Leitgeb study still resulted in results consistent with those in our study.

In contrast, two prior retrospective analyses that assessed sex differences in mortality following moderate/severe TBI among older adults reported decreased mortality for women. Davis et al. (2006) conducted a retrospective analysis using trauma registry data from 1987–2003.[6] Controlling for injury severity measures, post-menopausal women (age ≥50 years) were at decreased risk of mortality at discharge compared to age-matched men (OR 0.63; 95% CI 0.48, 0.81).[10] Berry and colleagues (2009) performed a similar analysis excluding individuals with AIS >2 for other body regions using data from the National Trauma Data Bank, 2000–2005, and reported that post-menopausal women (aged ≥55 years) were at decreased risk of mortality compared to similarly aged men (OR 0.79; 95% CI 0.73, 0.86).[7] These results are consistent with our analysis including all TBI cases (OR 0.73; 95% CI 0.59, 0.89), suggesting that residual confounding of the sex effect by injury to other body regions may explain previous discrepant results.

Consistent with prior studies, falls were the most common cause of TBI among older adults.[1,19,33] Even so, falls were more common in women than in men and accounted for a larger percentage of injuries among individuals with isolated TBI compared to all TBI cases. Older women were more likely than men to fall on the same level or on stairs. Men were more likely than women to have been injured in motor vehicle collisions in which they were the drivers. These differences in injury mechanism suggest that risk factors for TBI among older adults differ by sex. Identification of these factors could guide novel injury prevention efforts.

The disparity between initial GCS scores and anatomic severity of TBI among older adults is receiving increased attention.[19, 34–36] A recent study of 1,800 older adults admissions to a level 1 trauma center reported that 56% of severe TBI cases with a head AIS = 5 had only minor neurologic deficits (GCS 13–15).[36] This is consistent with our finding that 61% of isolated severe TBIs with a head AIS > 3 had a GCS score of 14–15. Our study extends current knowledge by reporting that women with severe anatomic TBI are even more likely than men to have higher initial levels of consciousness as indicated by high initial GCS scores. Heightened risk of severe TBI among older adults with low energy falls and minimal

initial neurologic deficit support recommendations that older adults with potential head injury should be evaluated at a trauma center.[19, 37–39]

We examined isolated TBI in this study because we wanted to eliminate possible confounding of a sex effect on TBI mortality by severity of other injuries. However, 73% of TBIs in our study occurred in conjunction with injury to other body regions, and these body regions differed by sex, likely as a result of differing injury mechanisms. Perhaps sex differences in injury to these other body regions not completely controlled by the ISS explains the differential mortality from TBI observed in previous analyses. Regardless, these results suggest that improvements in trauma and critical care will also result in reduced TBI mortality.

This study must be considered in light of several limitations. We used ICD-9-CM codes to identify individuals with TBI rather than AIS codes which may have excluded some individuals with TBI. Nonetheless, the ICD-9-CM codes we used are generated directly from the AIS codes in the trauma registry and are the codes recommended by the CDC for TBI surveillance. We also required an AIS head score of 1–6, ensuring that everyone in our study had TBI.[19,20] We lacked information on pre-injury medication use that could have been related to poorer outcome following TBI.

This study provides evidence that there are no sex differences in mortality among older adults following isolated TBI. Researchers should consider isolated TBI in outcome studies to prevent residual confounding by severity of other injuries. This analysis also comprehensively describes clinical and injury characteristics of older adults treated at a level 1 trauma center with TBI. Injury mechanism and type differed by sex, suggesting that risk factors for TBI among older adults may differ by sex. Identification of these factors could guide focused injury prevention efforts.

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Table 1

Demographic and Clinical Characteristics of Admissions aged 65 and Older to the R Adams Cowley Shock Trauma Center 1996–2012 with Isolated Traumatic Brain Injury by Sex, n= 1,320

Characteristic	Women N=590	Men N=730	P-value[1]
Age, mean (SD)	78.9 (7.7)	76.8 (7.5)	<0.001
Age, n(%)			<0.001
65–74	189 (32)	299 (41)	
75–84	252 (43)	303 (42)	
>85	149 (25)	128 (18)	
Race, n(%)			0.18
White	449 (76)	553 (76)	
Black	98 (17)	142 (19)	
Other	43 (7)	34 (5)	
Admission year, n(%)			0.96
1996–2000	118 (20)	153 (21)	
2001–2005	148 (25)	177 (24)	
2006–2010	216 (37)	264 (36)	
2011–2012	108 (18)	136 (19)	
Comorbid Conditions, n(%)			
Alcohol dependence	14 (2)	47 (6)	<0.001
Alzheimer's disease	27 (5)	24 (3)	0.23
Cardiac arrhythmia	37 (6)	42 (6)	0.69
COPD	26 (4)	36 (5)	0.65
Diabetes	129 (22)	145 (20)	0.37
Depression	45 (8)	32 (4)	0.01
Heart failure	36 (6)	46 (6)	0.88
Hypertension	346 (59)	385 (53)	0.03
Ischemic heart disease	37 (6)	54 (7)	0.42
Neurologic disorders	34 (6)	58 (8)	0.12
Stroke	49 (8)	80 (11)	0.11
Blood Alcohol Concentration in g/dL, n(%)			0.005
Negative	522 (88)	614 (84)	
<0.1	8 (1)	18 (2)	
≥0.1	20 (3)	55 (8)	
Missing[2]	40 (7)	43 (6)	
Admission systolic blood pressure, mm Hg, n(%)			0.12
<90	12 (2)	12 (2)	
90 to <120	41 (7)	43 (6)	

Characteristic	Women N=590	Men N=730	P-value[1]
120 to <140	74 (13)	113 (15)	
140 to <160	139 (24)	189 (25)	
160 to <180	121 (21)	171 (23)	
≥180	203 (34)	205 (28)	
Length of stay, n(%)			0.02
Early death (<1 day)	41 (7)	43 (6)	
< 2 days	246 (42)	294 (40)	
2 to 6 days	199 (34)	218 (30)	
1 to < 2 weeks	63 (11)	87 (12)	
2 to < 4 weeks	35 (6)	65 (9)	
≥ 4 weeks	6 (1)	23 (3)	
Expired at discharge, n(%)	96 (16)	123 (17)	0.78
Discharge location, n(%)			0.67
Home no services	222 (38)	256 (35)	
Home with services	24 (4)	26 (4)	
Other hospital/unit	232 (39)	306 (42)	
Other	15 (3)	18 (2)	

[1] P-value from Chi-square goodness of fit or Student's t-test;

[2] BAC missing for 1996

Table 2

Injury Characteristics of Admissions aged 65 and Older to the R Adams Cowley Shock Trauma Center 1996–2012 with Traumatic Brain Injury by Sex, n= 1,320

Characteristic	Women N=590	Men N=730	P-value[1]
Admission Glasgow Coma Score, n(%)			0.37
14–15	418 (71)	496 (68)	
9–13	83 (14)	103 (14)	
3–8	89 (15)	131 (18)	
Abbreviated injury scale score, head, n(%)			0.12
1	120 (20)	143 (20)	
2	21 (4)	16 (2)	
3	77 (13)	70 (10)	
4	225 (38)	305 (42)	
≥5	147 (25)	196 (27)	
Injury type, n(%)			0.005
Blunt	587 (99)	709 (97)	
Penetrating	1 (<1)	13 (2)	
Other	2 (<1)	8 (1)	
Transport to STC directly from scene, n(%)	283 (48)	326 (45)	0.23
Cause of injury, n(%)			<0.001
Motor vehicle collision	39 (7)	66 (9)	
Driver[2]	18 (46)	43 (65)	
Passenger[2]	12 (31)	7 (11)	
Pedestrian[2]	8 (21)	8 (12)	
Falls	535 (91)	612 (84)	
On stairs[3]	95 (18)	92 (15)	
Different level[3]	75 (14)	98 (16)	
Same level[3]	88 (16)	92 (15)	
Unspecified[3]	277 (52)	330 (54)	
Assault	12 (2)	34 (5)	
Other injuries/accidents	4 (1)	18 (2)	

[1] P-value from Chi-square goodness of fit or Student's t-test;

[2] Percent of total motor vehicle collisions;

[3] Percent of total falls

Table 3

Adjusted Odds (95% Confidence Interval) of Mortality at Discharge among Older Adults Treated for Isolated Traumatic Brain Injury at a Level 1 Trauma Center 1996–2012, n=1,320

	Odds Ratio (95% CI)
Female sex	1.01 (0.66, 1.54)
Age	1.07 (1.04, 1.10)
AIS[1] head score	
1	Reference
2	4.14 (0.40, 42.87)
3	9.70 (2.25, 41.85)
4	19.86 (5.48, 72.04)
≥5	81.50 (22.27, 298.19)
Glasgow Coma Scale score	
14–15	Reference
9–13	2.92 (1.70, 5.03)
<9	21.65 (13.19, 35.56)
Race	
White	Reference
Black	1.31 (0.76, 2.24)
Other	0.27 (0.10, 0.77)
Cardiac arrhythmia	2.75 (1.28, 5.94)
Admission systolic blood pressure	
< 90 mmHg	Reference
90 – <120 mmHg	0.15 (0.03, 0.66)
120 – <140 mmHg	0.21 (0.05, 0.84)
140 – <160 mmHg	0.14 (0.04, 0.51)
160 –<180 mmHg	0.10 (0.03, 0.40)
≥180 mmHg	0.11 (0.03, 0.43)
Transport to trauma center	
Directly from scene	Reference
Transfer from another hospital	0.26 (0.17, 0.42)

[1]Abbreviated Injury Scale

Table 4

Adjusted Odds (95% Confidence Interval) of Mortality at Discharge among Older Adults Treated for Traumatic Brain Injury at a Level 1 Trauma Center 1996–2012, n=4,854

	Odds Ratio (95% CI)
Female sex	0.73 (0.59, 0.89)
Age	1.07 (1.06, 1.09)
Admission year	0.94 (0.92, 0.96)
AIS[1] head score	
1	reference
2	1.81 (0.77, 4.22)
3	1.10 (0.69, 1.74)
4	1.12 (0.68, 1.85)
≥5	3.99 (2.21, 7.22)
Glasgow Coma Scale score	
14–15	reference
9–13	3.37 (2.60, 4.37)
<9	15.44 (11.98, 19.90)
Injury Severity Score	
<10	reference
10–15	3.90 (2.0, 7.61)
16–25	5.91 (3.04, 11.49)
>25	11.18 (4.97, 25.13)
Severity of other injuries	
No other injury (AIS[1] = 0)	reference
Mild (AIS[1] = 1,2)	0.59 (0.41, 0.85)
Moderate/severe (AIS[1] >2)	0.53 (0.31, 0.89)
Cardiac arrhythmia	1.94 (1.32, 2.83)
Admission systolic blood pressure	
< 90 mmHg	reference
90 –<120 mmHg	0.49 (0.29, 0.84)
120 – <140 mmHg	0.42 (0.25, 0.70)
140 – <160 mmHg	0.28 (0.17, 0.47)
160 – <180 mmHg	0.25 (0.15, 0.41)
≥180 mmHg	0.32 (0.20, 0.53)
AIS[1] face score	
0	Reference
1	1.22 (0.93, 1.60)
2	0.64 (0.43, 0.95)
3	1.08 (0.59, 1.97)
AIS[1] spine score	
0	reference

	Odds Ratio (95% CI)
1	0.41 (0.10, 1.69)
2	1.35 (0.98, 1.88)
3	2.46 (1.45, 4.16)
≥4	3.18 (1.68, 6.03)
AIS[1] thorax score	
0	reference
1	2.13 (1.28, 3.56)
2	1.11 (0.69, 1.81)
3	1.02 (0.66, 1.58)
≥4	1.46 (0.86, 2.47)
AIS[1] abdominal score	
0	reference
1	1.46 (1.01, 2.20)
2	1.26 (0.76, 2.06)
3	2.75 (1.27, 5.96)
≥4	5.72 (2.47, 13.21)
AIS[1] upper extremity score	
0	reference
1	1.17 (0.88, 1.56)
2	1.70 (1.19, 2.44)
3	0.82 (0.48, 1.38)
Transport to trauma center	
Directly from scene	reference
Transfer from another hospital	0.47 (0.37, 0.59)

[1]Abbreviated Injury Scale