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ORIGINAL ARTICLE

Geriatrics

Alcohol use is associated with intracranial hemorrhage in older emergency department head trauma patients

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Abstract

Objectives: Falls are common in adults aged 65 years and older and are the leading cause of traumatic brain injuries in this age group. Alcohol use may increase the risk of falls as well as the severity of resultant injuries. The aim of this study was to examine the association between self-reported alcohol use and the prevalence of intracranial hemorrhage (ICH) in this patient group.

Methods: This was a secondary analysis of the Geriatric Head Trauma Short Term Outcomes Project (GREAT STOP), a study of older adults with blunt head trauma from a fall. We determined the characteristics of every fall event, including patient demographics and medical history, and clinical signs and symptoms related to head trauma. Self-reported alcohol use was categorized as none, occasionally, weekly, or daily. We defined ICH as any acute ICH detected by computed tomography scan. We evaluated the association between alcohol use frequency and ICH, adjusted for patient factors and head injury risk factors.

Results: Of 3128 study participants, 18.2% ($n = 567$) reported alcohol use: 10.3% with occasional use, 1.9% with weekly use, and 6.0% with daily use. ICH was more common in patients who used alcohol (20.5%, 22.0%, and 25.1% for occasional, weekly, and daily alcohol users, respectively, vs. 12.0% for non-users, $p < 0.001$). The frequency of alcohol use was independently associated with ICH, adjusted for patient and head injury risk factors. The adjusted odds ratios (with 95% confidence intervals) for occasional, weekly, and daily alcohol users increased from 2.0 (1.5–2.8) to 2.1 (1.1–4.1) and 2.5 (1.7–3.6), respectively, and showed the characteristics of dose–response effect.

Conclusions: Alcohol use in older adult emergency department patients with head trauma is relatively common. Self-reported alcohol use appears to be associated with a higher risk of ICH in a dose-dependent fashion. Fall prevention strategies may need to consider alcohol mitigation as a modifiable risk factor.

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1 | INTRODUCTION

1.1 | Background

Falls are frequent among adults aged 65 years or older and are the leading cause of injury-related deaths in this population.[1] Falls are also the leading cause of traumatic brain injuries in older adults.[1] Over 3 million older adults visited an emergency department (ED) in the United States for a fall-related injury in 2019.[1,2]

Alcohol use further increases the fall-related injury risk in older adults.[3,4] Recent studies have shown that alcohol use and ED visits to the ED from alcohol-related falls among older adults in the United States are increasing.[5,6] A 2019 study found that 9% of older adults reported heavy alcohol use or binge drinking.[7] Furthermore, due to age-related changes, the effects of alcohol are greater in older individuals.[7,8]

The Bottom Line

Alcohol use in older adults is increasing. Few studies have assessed whether alcohol use in the geriatric population is associated with higher severity injury. This secondary analysis of a prospective study assessed the frequency of intracranial hemorrhage (ICH) related to alcohol use in geriatric emergency department patients who had fallen and sustained head trauma. Among 3128 patients, 19% reported alcohol use. ICH was more common in alcohol users than in non-alcohol users (22% vs. 12%) with daily alcohol users having the highest frequency. Alcohol use history in geriatric patients may need to be considered as a modifiable risk factor in fall prevention strategies.

1.2 | Importance

Few studies have examined whether alcohol use in older individuals is associated with fall-related injuries and their severity. A recent national study found that 2% of falls among older adults were associated with alcohol consumption.[9] Additionally, they also found that men who fell were more likely to consume alcohol than women and that, in older adults, heavy drinking tends to decrease among both men and women with increasing age.[9] Moreover, other studies have shown that higher blood alcohol concentration levels were associated with more severe forms of craniofacial and upper torso injuries.[9,10]

Since alcohol use is a potentially modifiable risk factor, it is important to obtain robust confirmation of the association between alcohol use and the risk for severe traumatic brain injury.

1.3 | Goals of this investigation

While previous studies have found an association between alcohol use and fall-related injuries, no studies have examined whether alcohol use is a risk factor for severe head injury in older adults. This study aimed to examine alcohol use and the incidence of intracranial hemorrhage (ICH) among older adults with head trauma due to a fall.

2 | METHODS

2.1 | Study design

This was a secondary analysis of an existing dataset from a large prospective study of older ED patients who sustained blunt head trauma following a fall. The study was approved by the Institutional Review Board of Florida Atlantic University.

2.2 | Data source

Data from the Geriatric Head Trauma Short Term Outcomes Project (GREAT STOP) were used for the current study.[11] This study included a prospective cohort of consecutive patients presenting to the EDs of Delray Medical Center and Bethesda Hospital East, two level one, university-affiliated trauma centers in Palm Beach County, Florida, USA. The EDs have annual volumes of 50,000 and 69,000 respectively. Study enrollment occurred for 1 year beginning in August 2019.

2.3 | Selection of participants

Patients aged ≥65 years who sustained blunt head trauma following a fall were included. Exclusion criteria were mechanism not due to a fall, injury occurring greater than 24 h prior to presentation, penetrating injuries or patients transferred to the facilities.

Trained research assistants (RAs) screened all older ED patients to enroll those with head trauma. In addition, all ED patients who received head computed tomography (CT) scans or had an ICD-10 code for a head injury (codes S00-S09) were screened to ensure identification of all patients who sustained head trauma.

The data collected by RAs included age, race, sex, smoking, alcohol use drug use, antiplatelet use, anticoagulant use, mechanism of injury, past medical history, loss of consciousness, Glasgow Coma Scale score, headache, seizure, vomiting, altered mental status, signs of head trauma, signs of basilar skull fracture, and abnormal neurological findings. These data were then entered into a REDCap database system with real-time data parameter validation built into the REDCap system. All enrolled patients had a chart review performed to ensure the integrity of the data. Data elements collected are shown in Table 1.

TABLE 1 Data collected (study variables of interest were selected after review of the minor head injury literature).

	Variables
Demographic information	Age, sex, ethnicity
Medical history	Co-morbidities (including coagulopathy, defined as a history of bleeding or a clotting disorder), medication use (including anticoagulant drug use and antiplatelet drug use), tobacco use history, alcohol use history, drug use history, dementia
Event history	Mechanism of injury, loss of consciousness, seizure (suspected or witnessed seizure after the traumatic event), method of transport to hospital
Symptoms	Dizziness, headache (any head pain, whether diffuse or local), memory loss (persistent anterograde amnesia with a normal Glasgow Coma Scale score), nausea, vomiting (any emesis after the traumatic event)
Signs	Agitation, altered mental status (acute) basal skull fracture signs, Glasgow Coma Scale, neurologic deficit (focal deficit), external signs of trauma above the clavicles (including contusions, abrasions, lacerations, deformities, and signs of facial or skull fracture)

2.4 | Exposure

All patients were asked about alcohol use and were asked to categorize their use as none, occasional, weekly, or daily. There is no consensus on methods to define alcohol consumption in older adults, but we considered this to be an appropriate surrogate measure of volume and frequency of alcohol use.[12]

2.5 | Outcomes

The primary study outcome was an ICH due to a fall associated with reported alcohol use. The reference group included patients with a fall-related head injury not associated with a history of alcohol use.

ICH was determined from the patient's head CT as read by the attending hospital radiologist. This physician was not part of the study team. The type of ICH was recorded as an epidural hematoma, intraparenchymal hemorrhage, intraventricular hemorrhage, subarachnoid hemorrhage, or subdural hematoma.

2.6 | Data analysis

Basic demographic data and clinical outcomes were determined for each subgroup of self-reported alcohol consumption, in addition to the rates of ICH in each subgroup.

To evaluate the differences in the prevalence of ICH between the subgroups, crude comparisons of ICH by alcohol use were performed by calculating risk differences (RDs) with 95% confidence intervals (CIs), applying an adjustment for multiple comparisons. Finally, two multivariable generalized logistic regression models were used to calculate adjusted odds ratios (aORs) and 95% CIs for ICH by alcohol use, adjusting for potential confounding variables. In the first multivariable model, we accounted for confounding variables related to patient-specific factors: age, sex, race, smoking, co-morbidities (including cognitive impairment), and antiplatelet or anticoagulant medication use. In the second multivariable model, we accounted for confounding variables related to significant clinical risk factors for ICH: reduced GCS score, anticoagulant medication use, antiplatelet medication use, loss of consciousness, headache, signs of head trauma, and signs of base of skull fracture. Statistical interactions between alcohol use and other variables were assessed using post-estimation Wald tests. Variables with $p < 0.05$ were included in the final multivariable model. Trends of ICH incidence related to alcohol use were evaluated both by crude analyses of RDs and a multivariable logistic regression test-of-trend analysis. Patients with missing data were excluded from the multivariate analyses. SPSS (IBM Corp., released 2022, IBM SPSS Statistics for Mac, version 29.0) was used for all analyses.

3 | RESULTS

A total of 3128 participants underwent an initial head CT following head trauma due to a fall. Among these patients, 433 (13.5%) had the primary outcome of ICH and 561 (18.2%) reported alcohol use. Participants with missing information about the frequency of alcohol use ($n = 375$) were excluded (Figure 1). Participants reporting binge drinking were also excluded because of small numbers ($n = 4$). The majority of respondents in the study were female, whereas males were most likely to report using alcohol. Weekly and daily alcohol users tended to be younger, with a mean age of 78 years, while non-alcohol users tended to be older, with a mean age of 83 years (Table 2).

ICH was more significantly common in alcohol users than in non-users (22% vs. 12%, chi-square test, $p < 0.001$). Notably, the prevalence of ICH increased with increasing frequency of alcohol use (see Figure 2). While the risk of ICH was already high for non-alcohol users (12.0%), the absolute RDs for ICH associated with alcohol use were substantial, rising from a risk increase of 8.5% in occasional alcohol users to an increase of 13.1% in daily alcohol users (see Table 3).

This same pattern emerged in our multivariable logistic regression models. The crude model, the patient risk factor-adjusted model, and the head injury risk factor-adjusted model showed very similar results. This suggested little collinearity between the frequency of alcohol use and other risk variables, that is, alcohol appears to be an independent risk factor for ICH (see Table 4). We observed that occasional alcohol use was associated with double the odds of ICH when compared to patients with no alcohol use (aOR 2.0, 95% CI 1.5–2.8, $p < 0.001$). Daily alcohol use was associated with 2.5-fold increased odds of ICH (aOR 2.5, 95% CI 1.7–3.6, $p < 0.001$).

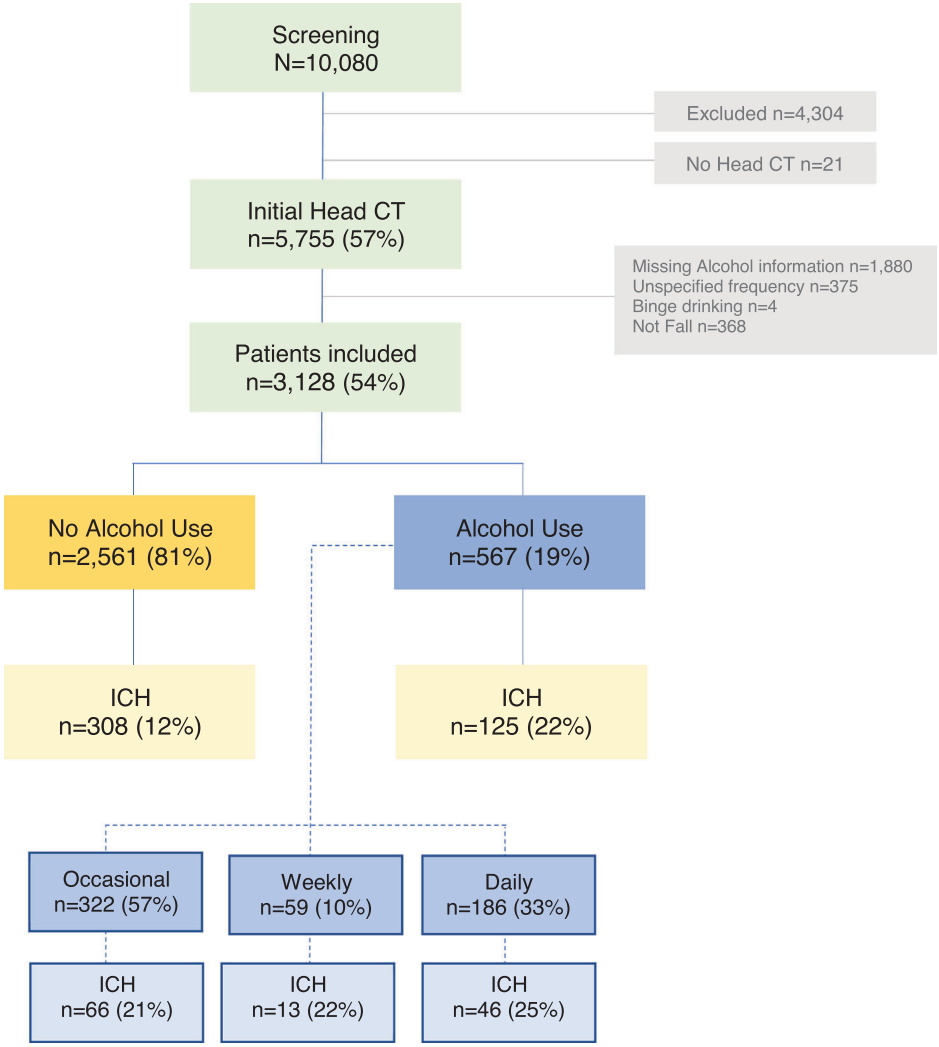

FIGURE 1 Flow chart.

TABLE 2 Characteristics of included participants presenting to the emergency department following head trauma by reported alcohol use.

		Frequency of alcohol use			
	***N* = 3128 (100%), % (*n*)**	**None, *n* = 2561 (81.8%), % (*n*)**	**Occasionally, *n* = 322 (10.3%), % (*n*)**	**Weekly, *n* = 59 (1.9%), % (*n*)**	**Daily, *n* = 186 (6.0%), % (*n*)**
Sex, % (*n*)					
Female	56.3 (1762)	59.1 (1513)	47.8 (154)	37.3 (22)	39.2 (73)
Ethnicity, % (*n*)					
Non-Hispanic	90.1 (2818)	89.9 (2302)	92.2 (297)	93.2 (55)	88.2 (164)
Hispanic	4.1 (128)	4.2 (108)	2.8 (9)	3.4 (2)	4.8 (9)
Unknown	5.8 (182)	5.9 (151)	5.0 (16)	3.4 (2)	7.0 (13)
Race, % (*n*)					
White	90.0 (2,814)	89.5 (2292)	92.2 (297)	93.2 (55)	91.4 (170)
Black	5.5 (173)	5.9 (152)	2.5 (8)	3.4 (2)	5.9 (11)
Other	4.5 (141)	4.6 (117)	5.3 (17)	3.4 (2)	2.7 (5)
Age, mean (SD)		83.3 (8.4)	81.6 (8.6)	79.5 (8.4)	78.4 (8.0)
Length of stay in days, mean (SD)		3.3 (4.1)	3.2 (3.6)	3.3 (3.1)	3.6 (3.7)

Abbreviation: SD, standard deviation.

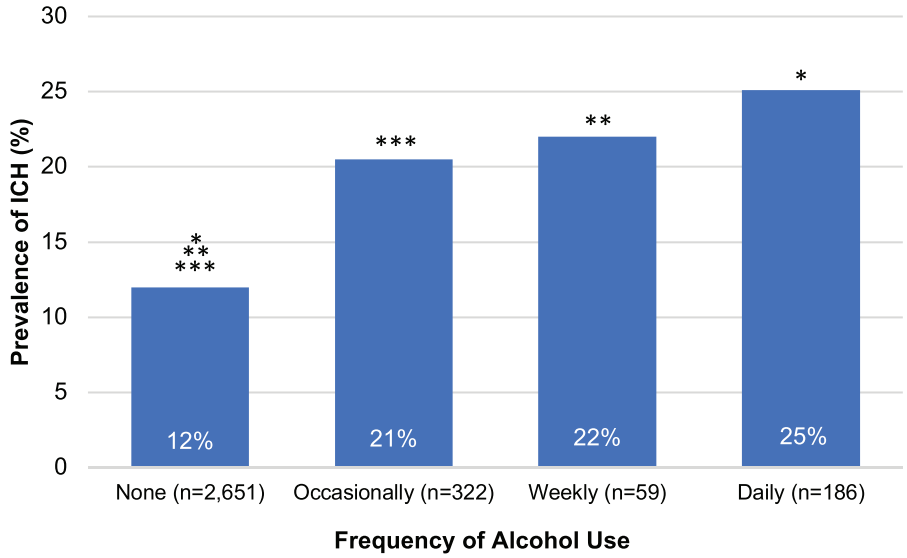

FIGURE 2 Prevalence of intracranial hemorrhage in each subgroup of self-reported alcohol use.

TABLE 3 Prevalence of intracranial hemorrhage in each subgroup of alcohol use, with the risk difference for each subgroup of alcohol use (exposed) when compared with the no alcohol use group (unexposed).

	Intracranial hemorrhage on CT		
Frequency of alcohol use	No (86.5% [2695]), % (*n*)	Yes (13.5% [433]), % (*n*)	Risk difference (95% CI)
None	88.0 (2253)	12.0 (308)	Reference
Occasionally	79.5 (256)	20.5 (66)	8.5 (4.0–13.0)
Weekly	77.9 (46)	22.0 (13)	10.0 (1.7–18.2)
Daily	74.9 (140)	25.1 (46)	13.1 (7.6–18.5)

Note: These values represent the absolute risk differences associated with alcohol use.
Abbreviation: CI, confidence interval; CT, computed tomography.

TABLE 4 Multivariable logistic regression results.

Frequency of alcohol use	Crude unadjusted model, OR (95% CI)	Patient risk factors adjusted model, aOR (95% CI)	Head injury risk factors adjusted model[a], aOR (95% CI)
None	Reference	Reference	Reference
Occasionally	1.9 (1.4–2.5)	1.9 (1.5–2.6)	2.0 (1.5–2.8)
Weekly	2.1 (1.1–3.9)	2.1 (1.1–4.1)	2.1 (1.1–4.1)
Daily	2.6 (1.8–3.4)	2.5 (1.7–3.6)	2.5 (1.7–3.6)
Confounders evaluated	N/A	Age, race, sex, smoking, drug use, dementia, hypertension, diabetes, CAD, cancer, AF, antiplatelet use, anticoagulant use	Mechanism of injury, LOC, GCS, headache, seizure, vomiting, AMS, signs of head trauma, signs of base of skull fracture, abnormal neurological findings
Confounders adjusted for in the final model	N/A	Antiplatelet use, anticoagulant use	Antiplatelet use, anticoagulant use, reduced GCS, LOC, headache, signs of head trauma, signs of base of skull fracture

Note: The crude odds ratios are shown for risk of intracranial hemorrhage. The aORs are shown for risk of intracranial hemorrhage adjusting for patient risk factors and head injury risk factors. These values represent the relative risk differences associated with alcohol use when compared with non-users. The result of the test-of-trend dose–response effect analysis (in the model adjusting for both patient and head injury risk factors) is shown in the bottom row. Coefficients (alcohol use categories) in each analysis were statistically significant predictors of the dependent variable (ICH) at $p < 0.001$.
Abbreviations: AF, atrial fibrillation; AMS, altered mental status; aOR, adjusted odds ratio; CAD, coronary artery disease; CI, confidence interval; GCS, Glasgow Coma Scale score; LOC, loss of consciousness; OR, odds ratio.
[a]Logistic regression test-of-trend aOR 1.4 (1.2–1.6); $p < 0.001$.

The apparent dose–response effect between the frequency of alcohol use and the prevalence of ICH was evident in both the absolute RD and the relative RD analyses. The multivariate logistic regression test-of-trend analysis confirmed this dose–response effect (aOR 1.4, 95% CI 1.2–1.6, $p < 0.001$). Thus, each increase in the frequency of alcohol use category (eg, occasional use to weekly use) is associated with a 40% elevated risk of ICH.

3.1 | Limitations

Our study has several limitations that warrant consideration. First, this study was a secondary analysis of prior dataset on head injury, and additional information on alcohol use was not available. Second, the data collection relied exclusively on self-reported responses. This method of data collection may underestimate the true prevalence of alcohol consumption due to social desirability bias. Third, approximately 33% of our study participants did not provide detailed alcohol use data. Some individuals who drink excessively may have not been willing to share this information. In addition, many of the study subjects had cognitive dysfunction and were unable to provide this history; however, these individuals were less likely to ingest alcohol, more frail and more likely to suffer serious injuries due to a fall. This would likely make it more difficult to show significant effects from alcohol.[13] Fourth, approximately 90% of our study subjects were Caucasian and non-Hispanic. This likely reflects the local demographics where the study was performed. This could affect the external validity of our findings. Finally, alcohol usage was not corroborated with alcohol testing. Although some patients did have alcohol levels, obtaining this test was performed at the discretion of the treating physician, and this was not a routine component of this study.

4 | DISCUSSION

Our study found that self-reported alcohol use among older adults with fall-related head trauma was significantly associated with increased risk of ICH. In addition, the data exhibited a significant dose–response effect evidenced by the greater odds of ICH for those participants who reported a higher frequency of alcohol use. This strong association between alcohol use and ICH appears to be an independent risk factor when accounting for other patient- and injury-related risk factors.

Little is known about the association between the frequency of alcohol use and the severity of injuries sustained after a fall in older adults. This is one of the first studies examining the relationship between self-reported alcohol use and severe head trauma in this group. A relatively high percentage (18.2% in our study) of older ED adults sustaining head trauma reported alcohol use, with 6% reporting "daily" alcohol use. This is similar to the findings from the Florida Behavioral Risk Factor Surveillance System's 2021 Data Book, which reported that 8.8% (6.7%–10.8%) of older adults admitting to "heavy" alcohol use.[14]

Several different alcohol screening and assessment tools are available. These include CAGE questions, TWEAK questionnaire, the Alcohol Use Disorders Identification Test (AUDIT-C), the National Institute on Alcohol Abuse and Alcoholism (NIAAA), and others. Our hospital study site was already utilizing a simple self-reported alcohol use scale which was used in this study. The results from this study provide some tentative support for the clinical utility of this screening method.

While falls remain the leading cause of both fatal and non-fatal injuries in older adults nationally, falls led to the deaths of 3805 older Floridians in 2021.[15] While some studies have hypothesized that alcohol use contributed to these outcomes, there are few studies which have examined this issue. Future research will be essential to confirm and expand on our findings.

One of the unexpected findings in our study was the strong dose–response relationship between reported alcohol use and ICH. The case for a potential causal link between alcohol use and ICH in older ED patients with head trauma is strengthened by the exposure–response association evidenced here.[16] Several other diseases have shown a similar association with increased alcohol consumption. Stroke, cardiovascular disease, cirrhosis, and certain cancers have also shown this relationship.[17–19] An underlying biological cause is therefore plausible and deserves additional research.

Our study's clinical implications are significant. Many risk factors for falling have been identified in older adults: polypharmacy, orthostatic hypotension, and home environmental dangers.[20] Our study findings warrant the consideration that alcohol use should be regarded as another important, independent, modifiable risk factor for falling. Alcohol may contribute to fall risk due to altered levels of sensorium, alteration in balance, and interference with concentration. It is also worth noting that as individuals age, the effects of alcohol are increased. This is because older adults often have a higher percentage of body fat to body water ratio, thus increasing the concentration of alcohol in the bloodstream. Furthermore, enzyme function associated with alcohol metabolism decreases with age, exacerbating this effect.[7,8] In this study, we were unable to determine whether acute intoxication was the risk factor for increased prevalence of ICH, or whether chronic alcohol use (even infrequent consumption) might induce pathophysiological changes which increase the risk for ICH. Some of these risk factors or changes could include dehydration, liver dysfunction with decreased clotting factors, malnutrition, electrolyte abnormalities (including hyponatremia), and seizures secondary to alcohol withdrawal.

Current fall prevention guidelines, such as the Center for Disease Control and Prevention's Stopping Elderly Accidents, Deaths & Injuries (STEADI) initiative or the American Geriatrics Society Clinical Practice Guidelines for Prevention of Falls in Older Adults, do not address the relationship between alcohol use and falls.[21–23] Our findings suggest that alcohol use assessment and mitigation strategies may be useful additions to fall prevention strategies. It will be important to establish through future research whether alcohol screening and alcohol abatement programs can decrease serious fall-related outcomes. Specifically, addressing alcohol use in campaigns to reduce falls and fall-related injury could be a worthy adjunct in fall prevention programs.[24]

In summary, alcohol use in older adult ED patients with head trauma is relatively common. Self-reported alcohol is significantly associated with a higher risk of ICH in a dose-dependent fashion. Fall prevention

strategies should consider alcohol use mitigation as a modifiable risk factor.

AUTHOR CONTRIBUTIONS

Richard D. Shih, Scott M. Alter, and Joshua J. Solano conceived the study, designed the trial, and obtained research funding. Richard D. Shih, Scott M. Alte, Joshua J. Solano, and Gabriella Engstrom supervised the conduct of the trial and data collection. Richard D. Shih, Scott M. Alte, Joshua J. Solano, and Gabriella Engstrom undertook recruitment of participating centers and patients and managed the data, including quality control. Mike Wells, Richard D. Shih, and Scott M. Alter provided statistical advice on study design and analyzed the data. Alexander Zirulnik and Shan Liu drafted the manuscript, and all authors contributed substantially to its revision. Richard D. Shih takes responsibility for the paper as a whole.

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CONFLICT OF INTEREST STATEMENT

The authors declare they have no conflicts of interest.

DATA AVAILABILITY STATEMENT

Partial or complete datasets and data dictionaries are available from publication date to 12/31/25 upon request to Dr. Shih at rshih@health.fau.edu and to investigators who provided an IRB letter of approval and study protocol.

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