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Increased Rates of Mild Traumatic Brain Injury among Older Adults in US Emergency Departments, 2009-2010:

Mild Traumatic Brain Injury in Older Adults

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Abstract

Objective—Estimate rates of emergency department (ED) visits for mild traumatic brain injury (TBI) among older adults. We defined possible mild TBI cases to assess underdiagnoses.

Design—Cross-sectional

Setting—National sample of ED visits 2009-2010 captured by The National Hospital Ambulatory Medical Care Survey.

Participants—Aged 65 and older

Measurements—Mild TBI defined by ICD-9-CM codes (800.0x-801.9x, 803.xx, 804.xx, 850.xx-854.1x, 950.1x-950.3x, 959.01) and a Glasgow Coma Scale score 14 or missing, excluding those admitted to the hospital. Possible mild TBI was defined similarly among those without mild TBI and with a fall or motor vehicle collision as cause of injury. We calculated rates of mild TBI and examined factors associated with diagnosis of mild TBI.

Results—Rates of ED visits for mild TBI were 386/100,000 among those 65-74; 777/100,000 among those 75-84; and 1,205/100,000 among those >84. Rates for women (706/100,000) were higher than for men (516/100,000). Compared to possible mTBI, diagnosis of mild TBI was more

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likely in the West (OR 2.31; 95%CI 1.02, 5.24) and less likely in the South/Midwest (OR 0.52; 95%CI 0.29, 0.96) than in the Northeast.

Conclusions—This study highlights an upward trend in rates of ED visits for mild TBI among older adults.

Keywords

mild traumatic brain injury; NHAMCS; older adults; emergency departments

Introduction

Traumatic brain injury (TBI) resulted in 142,000 emergency department (ED) visits and 81,500 hospitalizations annually among adults 65 and older in the United States during 2002-2006.¹ Rates of TBI-related ED visits among older adults increased steadily from 3.7/1,000 in 2001 to 6.0/1,000 in 2010.² Combined with the growth in the population of older adults, accelerating rates of TBI will result in a future surge in the number of older adults presenting to the ED with TBI.³ The majority (>75%) of these individuals will have mild TBI.^{5,6}

Mild TBI is usually defined as injury to the brain resulting in no more than thirty minutes loss of consciousness and/or less than 24 hours of post-traumatic amnesia and/or neurological deficits (often operationalized by a Glasgow Coma Scale (GCS) score of 13-15).^{5,7} Diagnosis of mild TBI is difficult due to the absence of well-defined clinical criteria and among older adults is further complicated by the presence of comorbid conditions, medication use, and pre-injury cognitive impairment which can disguise symptoms of mild TBI.⁸⁻¹⁰ Furthermore, age-related increases in intracranial space and anticoagulant use make bleeding more likely among older adults while at the same time decreasing the likelihood that GCS scores would indicate serious injury.^{11,12} Consequently, mild TBI among older adults is most likely underdiagnosed.^{10, 13-16} This may have important consequences for older adults in terms of identification and treatment of functional and psychiatric sequelae of mild TBI.¹⁷⁻²³ Left untreated, these sequelae could lead to functional decline and potentially to loss of independence for the older adult.

The 2003 Report to Congress on Mild TBI recommended use of the National Hospital Ambulatory Medical Care Survey (NHAMCS) for surveillance and earlier studies have used these data to estimate the number of TBI cases (all severities) seen in US EDs.^{1,5,24-26} However, there has been no updated analysis of these data since 2008 and none have attempted to separate out mild TBI or look specifically at rates in different age groups among the elderly. This is particularly important given that the NHAMCS did not begin collecting GCS scores until 2009, and these prior studies relied solely on ICD-9 codes, sometimes with the addition of other variables such as receipt of a CT scan, to determine TBI severity. The objective of this current study is to estimate sex and age-specific rates of older adults seen in US EDs with mild TBI using improved data from the 2009 and 2010 NHAMCS that include the GCS to determine TBI severity. In addition, we seek to define a group of possible mild TBI cases and examine diagnostic practices.

Methods

Data Source

The NHAMCS is one of the National Health Care Surveys conducted by the National Center for Health Statistics.²⁷ It constitutes a national probability sample of visits to the emergency and outpatient departments of non-institutional general and short-stay hospitals (excluding Federal, military, and Veterans Administration hospitals) and was designed to provide estimates based on the following priority of survey objectives: United States, region, emergency and outpatient departments, and type of ownership. The NHAMCS uses a four-stage probability design with samples of primary sampling units (PSUs), hospitals within PSUs, clinics and emergency service areas within hospitals, and patient visits within clinics and emergency service areas. PSUs are geographic segments composed of counties, groups of counties, county equivalents or towns, townships, or a metropolitan statistical area. The sampling unit is the patient visit, and is systematically selected over a 4-week reporting period. The target number of patient record forms completed for each participating ED was 100. Staff at each hospital were trained by U.S. Bureau of the Census field workers on completion of the patient record forms for the NHAMCS. For this study, we merged the hospital ED modules from 2009 and 2010.

Case Definition

The Centers for Disease Control and Prevention's (CDC) defines TBI of any severity based on any of the following ICD-9-CM codes: 800.0x-801.9x, 803.xx, 804.xx, 850.xx-854.1x, 950.1x-950.3x, 959.01.²⁸ We searched for these codes in any of the three ICD-9 diagnosis code fields available in the 2009-2010 NHAMCS. The American College of Emergency Physicians (ACEP) recommends using GCS scores of 14-15, rather than 13-15 for mild TBI case definition because of the high incidence of lesions requiring neurosurgical intervention among individuals with GCS scores of 13.⁶ Therefore, we defined mild TBI using the CDC's ICD-9-CM based definition of TBI in combination with a GCS score 14-15 or a missing GCS score. If the GCS score was missing, we required that the individual did not die in the ED. The rationale for including missing GCS scores was that patients with less severe head injury were more likely to have a missing GCS score. We defined moderate/severe TBI as any of the CDC's ICD-9 –CM codes in combination with a GCS $\leq$ 13. To make our results comparable with the CDC's report on TBI in the ED and further ensure that we included only mild TBI cases, we excluded visits resulting in hospitalization.¹

We were interested in understanding factors that were associated with receiving a diagnosis of mild TBI. We constructed a comparator group of ED visits that were not diagnosed with TBI. We defined these 'possible' mild TBIs as visits with a GCS score of 14-15, a fall or motor vehicle collision as cause of injury, and required that individuals with missing GCS scores did not die in the ED, consistent with our mild TBI definition. We excluded moderate and severe TBI and visits resulting in hospitalization.

Variables

Information collected for the NHAMCS includes patient demographics (age, sex, race and ethnicity, current residence), visit information (length of stay, waiting time, payment source,

discharge disposition, ICU/hospital admission, reason for visit), clinical variables (vital signs, the GCS, procedures and diagnostics, three ICD-9-CM diagnosis code fields, and three cause of injury fields), and hospital-level variables (region, metropolitan area, ownership). In addition, information on five comorbidities (cerebrovascular disease, heart failure, conditions requiring dialysis, HIV, and diabetes) was collected. We searched the three injury cause fields for E codes 880.x-888.x (falls) and 810.x-819.x (motor vehicle collisions).

Data Analysis

We calculated age-adjusted rates of ED visits for mild TBI using the 2010 United States Census standard population and stratified them by age category (65 years to <75 years, 75 years to <85 years, and ≥ 85 years) and sex. We generated 95% confidence intervals (CI) using weighted frequencies. The NHAMCS cautions that estimates based on fewer than thirty (unweighted) records or with a standard error $> 30\%$ are considered unreliable; therefore, we report only estimates meeting NHAMCS criteria.²⁷ We combined categories of certain variables (e.g. South and Midwest regions) and created dichotomous variables (e.g. Non-profit facility vs. all other types of facilities). We calculated descriptive statistics for all covariates separately for mild TBI and possible mild TBI and used NHAMCS weights to generate national estimates of frequencies and percentages that account for the survey's complex sampling design. We also report unweighted frequencies to enhance understanding of underlying data.

We created two domains representing adults aged 65 and older with mild and possible mild TBI visits. Next we tested for differences in the distribution of covariates between mild TBI and possible mild TBI by constructing logistic regression models that modeled the odds of mild TBI as a function of each covariate using weighted domain analysis. This was accomplished with the Surveylogistic procedure in SAS to account for the survey's complex sampling design. We used a p-value of 0.1 as a cut point to determine which variables to include in our adjusted logistic regression models, and modeled the odds of mild TBI as a function of identified covariates using weighted domain analysis.

We conducted multiple sensitivity analyses to determine the robustness of our results to modifications of our mild TBI definition. To determine if our exclusion of hospitalized mild TBI cases influenced our results, we conducted a sensitivity analysis including these cases. To determine if our inclusion of visits with missing GCS scores altered our results, we also conducted a sensitivity analysis excluding these cases. Finally, we used the exact criteria that were used in the 2010 CDC report to define a TBI ED visit. This meant not using GCS scores and excluding hospitalized cases, those who died in the ED, and those who were transferred to another facility. Odds ratios and 95% confidence intervals are reported. Statistical significance was defined as $p < 0.05$.

The institutional review board at the University of Maryland, Baltimore determined that this study was exempt from IRB oversight because of the use of publically available, fully de-identified data. Data analysis was performed using SAS version 9.3 (SAS Institute, Cary, NC).

Results

For the two year period 2009-2010, there were an estimated 265,915,507 visits to EDs in the United States and 14.8% were by adults aged 65 and older (N= 39,272,341). Among older adults, 502,908 visits (1.3%) were diagnosed with mild TBI and 3,890,968 (9.9%) had possible mild TBI. Among diagnosed mild TBI cases, 57.8% had a missing GCS score while 66.5% had a missing GCS score in the possible mild TBI group. Average age of those with diagnosed mild TBI was 79.1 [95% confidence interval (CI) 77.3, 81.0], 87.8% were white, and 64.3% were female (Table 1). The most common cause of injury was a fall (80.1%), followed by a motor vehicle collision (4.4%). Comorbidities are not well reported in the NHAMCS and did not appear in frequencies high enough to report, even when we made a variable representing more than one comorbid condition.

The overall age-adjusted annual rate of ED visits for diagnosed mild TBI in adults aged 65 and older that did not result in hospitalization, averaged over the two year study period, was 624 visits/100,000 (95% CI 622 - 627/100,000) persons. Stratified by age category, the annual rate for visits aged 65 years to < 75 years was 386/100,000 (95% CI 383 - 388/100,000) persons; 777/100,000 (95% CI 773 - 782/100,000) for visits aged 75 years to < 85 years; and 1,205/100,000 (95% CI 1,196 - 1,214/100,000) for visits aged $\geq$ 85 years. Among women aged 65 and older, the annual rate of ED visits for diagnosed mild TBI was 706/100,000 (95% CI 703-709/100,000) and among men it was 516/100,000 (95% CI 513 - 519/100,000).

Distribution of covariates was similar between visits with diagnosed mild TBI and those with possible mild TBI with some exceptions. Visits with diagnosed mild TBI were more likely to have occurred in the Northeastern (31.0% vs. 19.9%) and Western census regions (28.1% vs. 18.3%) ($p=0.002$ for all) compared to visits with possible mild TBI. Visits with diagnosed mild TBI were much more likely to have arrived at the emergency department by ambulance (61.6% vs. 42.9%, $p=0.002$), received a CT scan of the head (88.1% vs. 23.8%, $p<0.001$), and to have received more than three diagnostic tests (35.6% vs. 21.5%, $p=0.004$) compared to visits with possible mild TBI.

Our adjusted logistic regression model contained indicator variables for region, ownership, metropolitan region, CT scan of the head, more than three diagnostic procedures, and arrival by ambulance (Table 2). Compared to possible mild TBI, diagnosis of mild TBI was more likely in the West (OR 2.31; 95% CI 1.02, 5.24) and less likely in the South and Midwest (OR 0.52; 95% CI 0.29, 0.96) compared to the Northeast. Compared to visits with possible mild TBI, those with diagnosed mild TBI were more likely to be treated in non-profit hospitals (OR 3.05; 95% CI 1.45, 6.43) and to have had a CT scan of the head (odds ratio (OR) 25.21; 95% CI 12.76, 49.81).

In sensitivity analysis including hospitalized mild TBI cases, visits diagnosed with mild TBI were more likely in the West (OR 2.05; 95% CI 1.02, 4.13) when compared to visits in the Northeast. (results not shown) Visits with diagnosed mild TBI were more likely to have had a CT scan of the head (odds ratio (OR) 22.76; 95% CI 12.60, 41.10). In sensitivity analysis excluding visits with missing GCS scores, visits with diagnosed mild TBI were more likely

to have had a CT scan of the head (odds ratio (OR) 39.49; 95% CI 10.13, 153.89) compared to possible mild TBI. In our sensitivity analysis using the CDC's criteria, all associations were similar with one exception. Visits diagnosed with mild TBI were still less likely in the South and Midwest (OR 0.61; 95% CI 0.36, 1.02) than a possible mild TBI diagnosis when compared to visits in the Northeast, but this association was no longer statistically significant.

Discussion

The frequency of ED visits for mild TBI among older adults in the US has increased considerably since the CDC's 2010 report on TBI in the US.¹ Based on 2002-2006 data, the CDC reported that the average rate of visits for TBI not resulting in hospitalization among older adults was 390/100,000.¹ The rate we report from 2009-2010 (631/100,000) represents a 61% increase over the past few years. Using the same CDC criteria for ED visits for TBI from the 2010 report, we calculated a rate of 628/100,000, still a 61% increase. Among adults aged 75 and older, there was a 69% increase over previously published rates.¹ A prior study using NHAMCS data from 2006-2008 also reported an increased frequency of ED visits for TBI (all severities) among older adults but did not exclude hospitalized cases or calculate rates.²² Using that study's inclusion criteria, our estimated rate of ED visits for TBI (any severity) among older adults from 2009-2010 is even higher (819/100,000). Reasons for the increased rates of ED visits for mild TBI may include enhanced public health awareness leading to increased screening for mild TBI, active lifestyles that boost risk of falls, and an expanding proportion of older adults with higher fall risk.²⁹

Rates of ED visits for mild TBI among adults aged 75-84 years were double those observed among adults aged 65-74 years and among adults aged 85 and older, rates were triple those observed among adults aged 65-74 years. These results are concordant with those of a study using data on TBI hospitalization in Australia that reported that rates of hospitalization among adults aged 75-85 were double the rates observed among those aged 65-74.³⁰ Rates of ED visits for mild TBI among older adults were higher in women than in men. Although this is contrary to literature that has reported higher incidence rates of TBI in men, it is consistent with two studies we conducted in Medicare beneficiaries hospitalized with TBI.^{17,30-32} Most prior research has been conducted in younger populations therefore one explanation for this discrepancy is age. Women may also be more likely to seek medical attention following mild TBI.³³

We observed regional variation in diagnosis of mild TBI among older adults when comparisons were made with the possible mild TBI group, with visits in the South less likely to receive a mild TBI diagnosis and visits in the West more likely to receive a mild TBI diagnosis. Geographic variation in diagnoses of chronic conditions has previously been reported among Medicare beneficiaries.^{34,35} Hospitalization rates for mild TBI could account for regional variation. In a study using NHAMCS data, patients in the Northeast were more likely to be hospitalized for transient ischemic attack compared with patients in other regions.³⁶ To determine if geographic variation in hospitalization rates for mild TBI accounted for our observed variation in diagnoses, we conducted a sensitivity analysis by including visits that resulted in a hospitalization in our mild TBI and possible mild TBI

groups. Results from this analysis suggest that variation in hospitalization rates for mild TBI does not wholly explain the variation in diagnoses among older adults. Visits in the West were still more likely to receive a diagnosis. This observed variation requires further study, particularly with regard to outcomes following treatment.

Results from this study should be interpreted with caution. Prior studies have suggested that the CDC's ICD-9-CM codes for mild TBI surveillance have poor sensitivity to detect clinically defined mild TBI and that mild TBI is underdiagnosed.^{10,13-16,37} In this study we used the CDC recommended ICD-9-CM codes for TBI of all severities in conjunction with the GCS and other criteria to isolate mild TBI.⁵ These codes are recommended for national TBI surveillance and have been used to generate prior estimates against which we compare our results, suggesting that relative increases in observed rates should not be affected by the sensitivity of the ICD-9-CM codes or under diagnosis of mild TBI but we may be underestimating the absolute rates.^{1,5,25,26} Although we used GCS scores to increase the sensitivity of ICD-9 codes to detect mild TBI, these scores were missing in 58% of the sample. Reasons for the missing scores are unknown and our assumption that GCS scores were more likely to be missing in mild TBI visits needs to be tested. Nonetheless, our exclusion of hospitalized visits and those who died in the ED increases the likelihood that those with missing GCS scores were mild TBI visits. Results from our sensitivity analysis excluding missing GCS scores indicated that the direction of observed associations did not change, although in some cases they were no longer statistically significant. The NHAMCS contains only three fields for diagnosis codes. Other mild TBI cases may have been identified with additional diagnosis code fields, suggesting that we may be underestimating rates of mild TBI visits to the ED. Nevertheless, the NHAMCS has been used previously to estimate national rates of TBI; hence, our estimates are comparable with those prior reports.^{1,25,26,38} The NHAMCS data are collected at the visit rather than the patient level; hence, reported rates of mild TBI should be interpreted as such. Finally, this study does not include visits to federal, military, and Veterans Administration hospitals.

This study updates national rates of ED visits for mild TBI among older adults and highlights an alarming upward trend. Enhanced education and discussion regarding fall prevention that includes exercise, medication review, vision screening, and tips to reduce trip hazards in the home may help stabilize or reduce rates of mild TBI.^{39,40} Regional variation in receipt of a mild TBI diagnosis suggests under diagnosis of mild TBI and requires further study. Increased rates of ED visits for mild TBI among older adults emphasize the need for research to understand causes and outcomes of mild TBI in order to minimize the impact of this injury in the elderly.

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Characteristics of Adults 65 Years Old Seen in United States Emergency Departments 2009-2010 with Diagnosed or Possible Mild Traumatic Brain Injury

Table 1

	Mild TBI N=135 (weighted n=502,908)			Possible Mild TBI N=1,008 (weighted n= 3,890,968)			Wald Chi-square p-value ^a
	Actual frequency ^b	Weighted Frequency	% (95% Confidence interval)	Actual frequency ^b	Weighted Frequency	% (95% Confidence interval)	
Age, mean (95% CI)			79.1 (77.3, 81.0)			78.2 (77.5, 78.8)	0.22
Age categories							0.44
65-74	49	167,468	33.3 (23.1, 43.5)		1,521,855	39.1 (35.3, 42.9)	
75-84	54	203,060	40.4 (29.6, 51.2)	361	1,377,707	35.4 (31.7, 39.1)	
> 84	32	132,380	26.3 (16.1, 36.5)	255	991,406	25.5 (22.1, 28.9)	
Female sex	86	325,561	64.7 (53.9, 74.8)	661	2,540,197	65.3 (61.6, 69.0)	0.69
White race	118	441,306	87.8 (79.8, 95.7)	862	3,348,759	86.1 (83.4, 88.8)	0.86
Glasgow Coma Scale							0.12
14-15	49	213,741	42.5 (31.4, 53.6)	329	1,303,146	33.5 (29.8, 37.2)	
missing	86	289,167	57.5 (46.4, 68.6)	679	2,587,822	66.5 (62.8, 70.2)	
Fall cause of injury	111	402,670	80.1 (71.1, 89.1)	891	3,415,125	87.8 (85.1, 90.4)	0.25
Medicare	116	435,182	86.5 (78.7, 94.4)	810	3,133,216	80.5 (77.5, 83.5)	0.26
Year							0.23
2009	65	215,021	42.8 (32.0, 53.5)	505	1,993,178	51.2 (47.3, 55.1)	
2010	70	287,887	57.2 (46.5, 68.0)	503	1,897,790	48.8 (44.9, 52.7)	
Region							0.002
Northeast	50	155,931	31.0 (21.5, 40.5)	268	774,606	19.9 (17.1, 22.7)	
West	32	141,194	28.1 (17.5, 38.7)	172	711,537	18.3 (15.1, 24.4)	
Midwest and South	53	205,783	40.9 (30.0, 51.8)	568	2,404,825	61.8 (58.1, 65.5)	
Metropolitan area	120	433,046	86.1 (78.7, 93.6)	800	2,917,052	75.0 (71.4, 78.5)	0.05
Non-profit facility	119	442,807	88.0 (81.3, 94.8)	780	2,984,551	76.7 (73.5, 79.9)	0.08
Arrival by ambulance	71	295,856	61.6 (51.2, 72.0)	408	1,610,685	42.9 (38.9, 46.8)	0.002
Private residence	107	374,429	74.5 (64.4, 84.5)	813	3,113,590	80.0 (76.9, 83.2)	0.35
CT scan of head	114	442,937	88.1 (81.8, 94.4)	254	927,281	23.8 (20.6, 27.1)	<0.001

	Mild TBI N=135 (weighted n=502,908)			Possible Mild TBI N=1,008 (weighted n= 3,890,968)			Wald Chi-square p-value ^a
	Actual frequency ^b	Weighted Frequency	% (95% Confidence interval)	Actual frequency ^b	Weighted Frequency	% (95% Confidence interval)	
> 3 diagnostic tests performed	49	178,927	35.6 (25.2, 46.0)	232	836,518	21.5 (18.4, 24.6)	0.004

^aWald Chi-square test from individual logistic regression analysis

^bThe NHAMCS cautions that estimates based on less than 30 records are considered unreliable and should be confirmed in larger samples.

Table 2

Adjusted^a Odds Ratios (95% Confidence Intervals) of Mild Traumatic Brain Injury Diagnosis among Older Adults with Possible Head Injury Who Presented To Hospital Emergency Departments in the United States, 2009-2010, n=380 (weighted 1,401,674)

	Odds Ratio (95% Confidence Interval)	Wald Chi-Square p-value
Region		
Northeast	Reference	
West	2.31 (1.01, 4.81)	0.002
South and Midwest	0.52 (0.29, 0.96)	<0.001
Ownership		
Not Voluntary non-profit	Reference	
Voluntary non-profit	3.05 (1.45, 6.43)	0.003
Metropolitan region		
No	Reference	
Yes	1.01 (0.48, 2.13)	0.99
CT scan head		
Not received	Reference	
Received	25.21 (12.76, 49.81)	<0.001
Diagnostic procedures		
3	Reference	
>3	0.78 (0.44, 1.36)	0.34
Arrival by ambulance		
No	Reference	
Yes	1.14 (0.66, 1.99)	0.64

^aModel adjusted for covariates shown in table.