Title: Trends in incidence and severity of sports-related traumatic brain injury (TBI) in the emergency department, 2006-2011

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Abstract

Objective: To characterize and identify trends in sports-related traumatic brain injury (TBI) ED visits from 2006-2011.

Methods: We reviewed TBI data on sports-related TBI among individuals under age 65 from the Nationwide Emergency Department Sample from 2006-2011. Visits were stratified by age, sex, injury severity, payer status, and other criteria. Variations in incidence and severity were examined both between groups and over time. Odds of inpatient admission were calculated using regression modeling.

Results: Over the period examined, 489,572 sports-related TBI ED visits were reported. The majority (62.2%) of these visits occurred among males under the age of 18. The average head Abbreviated Injury Severity score among these individuals was 1.93 (95% CI: 1.93-1.94), and tended to be lowest among those in middle school and high school age groups; these were also less likely to be admitted. The absolute annual number of visits grew 65.9% from 2006-2011, with the majority of this growth occurring among children under age 15. Hospitalization rates dropped 35.6% over the same period.

Conclusion: Changes in year-over-year presentation rates vs. hospitalization rates among young athletes suggest that players, coaches, and parents may be more aware of sports-related TBI and have developed lower thresholds for seeking medical attention.

Introduction

Background

The Centers for Disease Control and Prevention (CDC) estimates that traumatic brain injury (TBI) affects over 2.5 million individuals annually.¹ Sports have been recognized as playing a significant role in the incidence of TBI in recent years, and in response, 43 states and the District of Columbia have instituted so-called “Return-to-play” laws establishing guidelines for the prevention and treatment of TBI among school-aged participants in multiple sports.² These legislative efforts, combined with campaigns by the CDC in conjunction with the National Football League (NFL), the National Collegiate Athletic Association (NCAA), the National Federation of State High School Associations (NFHS), and others, have been targeted primarily at young athletes, their coaches, and families.^{3,4}

In addition to instituting policies regarding the signs, symptoms, and evidence-based treatment of sports-related TBI, these campaigns have sought to raise awareness of concussion and TBI along with possible short-and long-term changes associated with TBI. The NCAA has implemented and publicized football rules prescribing harsh consequences for helmet-to-helmet contact and establishing a mandatory one-down break for players who lose their helmet in play; indeed, the focus on TBI prevention has been nearly impossible to miss among those with even a passing interest in sports.⁵ The impact TBI awareness campaigns, return-to-play laws, and other regulations are having on the incidence and treatment of TBI among athletes has yet to be determined.

Importance

One purpose of the introduction of new rules and training campaigns is to increase knowledge of the potential severity and consequences of sustaining a TBI while participating in sports. Increased awareness may precipitate increased utilization of safety measures and, at the same time, may lead to higher rates of injury reporting and follow-up. Research is needed to examine possible changes in sport-related TBI presentation and treatment in U.S. emergency departments (ED) over time.

Goals of this Investigation

We sought to identify and characterize trends in presentation for ED treatment of sports-related TBI, injury severity, and patient ED outcomes across several age groups, and to identify factors that are associated with inpatient hospitalization.

Methods

Selection

TBI data were collected from the Nationwide Emergency Department Sample (NEDS) of the Healthcare Cost and Utilization Project (HCUP) of the Agency for Healthcare Research and Quality (AHRQ). The NEDS is the nation's largest all-payer ED database.⁶ For 2011, the NEDS included data from over 950 hospitals in 30 states. The Johns Hopkins Medical Institutions Institutional Review Board approved this study.

We identified individuals from the NEDS database who carried a primary diagnosis of TBI (as identified using the International Classification of Diseases, ninth edition [800.0-801.9, 803.0-804.9 and 850.0-854.19, as recommended by the CDC]).⁷ From this subset, we identified individuals whose mechanism of injury was sports-related (E-codes 917.0 and 917.5). Because fewer than 0.1% of sports-related TBI occurred among individuals age 65 and older, these individuals were excluded from this analysis.

Methods and measurements

Abbreviated Injury Scale scores (AIS) were calculated for each subject.⁸ Geographic regional differences were examined across the Northeast, South, Midwest, and West, as defined in the NEDS based on the U.S census regional demarcations. Few patients identified Medicare as their primary payer so Medicare and Medicaid patients were combined into a single “government insurance” category.

Outcomes

Two types of outcomes were measured: incidence and severity of injury. Severity was assessed at the individual level using head AIS scores and at the population level examining the overall rate of hospitalization. Patients with missing data were generally included for analysis with missing values listed as a separate category.

Analysis

All statistical analyses were conducted using the Stata 12.1 MP statistical software package (StataCorp, College Station, Texas). We used the Stata module International Classification of Diseases Program for Injury Categorization (ICDPIC) [available:

<http://ideas.repec.org/c/boc/bocode/s457028.html>] to calculate head-specific AIS scores. AIS scores for the head and neck range from 1 (“minor”) to 6 (“unsurvivable”).

TBI incidence and severity among school-age athletes was of particular interest, so groupings associated with approximate age of entry and exit of middle school (age 12-14), high school (age 15-18), and college (age 19-23) were created. USA Census data and intercensal estimates are based on five-year age groupings (age 10-14, 15-19), which limited our ability to calculate precise population-based incidence rates for these strata.⁹ For certain comparisons, head AIS scores were grouped into categories of 1-2, 3-4, or 5-6.

Chi square tests were used to compare proportions between and among annual cases. Multivariable logistic regression modeling was used to calculate the adjusted odds of inpatient hospitalization among those presenting to the ED with a primary diagnosis of sports-related TBI. Models were adjusted for sex, age, head injury severity (head AIS score), payer, and hospital region. When calculating the odds of inpatient admission from the ED, data were aggregated across all years.

Results

Characteristics of study population

From 2006 to 2011, a total of 487,221 cases of sports-related TBI among individuals age 65 and younger presented to the ED in the USA. Males constituted 368,474 (75.6%) of the sports-related TBI over the study period (table 1). The proportion of male patients varied by age, ranging from a high of 81.6% in children under age 12 to a low of 71.4% in adults over age 24 (table 1).

Insert table 1 about here

Young people made up the majority of all sports-related TBI visits to the ED, with 435,824 (89.5%) occurring in individuals younger than age 24. Middle school and high school-age athletes bore a significant portion of the TBI burden, with 319,071 (65.5%) of cases occurring among those aged 12-18. Most patients (364,307, or 74.8%) were privately insured and Government insurance was the second most common method of payment encompassing 67,173 (13.8%) visits. The vast majority (96.5%) of patients had head AIS scores of either 1 or 2. The proportion of individuals with more severe injury (AIS score 3 or 4) ranged from a low of 2.3% among 12-14 year olds to 9.5% among those age 24 and older.

Main results

Overall 3.7% (95% CI: 3.5-4.0) of ED visits across the study period resulted in admission to inpatient status, and ED patients over age 24 were proportionally most likely to be admitted. There were no significant regional variations in inpatient admission rates. Adjusted odds of admission were lower among all age groups except those under age 12 when compared with adults over age 24 (table 2). Females had 21% lower odds of admission compared with males (OR= 0.79; 95% CI: 0.72, 0.87), and the odds of inpatient admission were significantly higher in the West (OR=1.39 95% CI: 1.11, 1.75) and Midwest (OR=1.38; 95% CI: 1.06, 1.79), compared with the Northeast.

Insert table 2 about here

TBI-related ED visits over time

From 2006 to 2011, the number of individuals presenting to the ED for sports-related TBI among all age groups grew 65.9%, from 63,516 to 105,384 (table 3). The

greatest increases were observed among middle school-aged children (94.9% increase) and those under age 12 (71.7% increase).

Insert table 3 about here

The proportion of ED presentations resulting in admission to the hospital dropped from 4.4% in 2006 to 2.8% in 2011, while the total number of sports-related TBI admissions remained relatively stable 2,808 in 2006 vs. 2,996 in 2011.

Limitations

This analysis is subject to limitations associated with large administrative data sets, including lack of specificity in E-coding, which may have biased our findings. Additionally, our findings may underestimate the incidence of sports-related TBI, as they may not detect all sports-related head trauma because of variability in reporting and coding. Further, this study was limited by the cross-sectional nature of the NEDS dataset; for example, it was not possible to identify individuals with multiple presentations for sports-related TBI, nor could outcomes beyond hospital discharge be examined.

Discussion

Sports-related TBI can have short- or long-term consequences.¹⁰ State legislatures and sports governing bodies are to be applauded for their efforts to protect athletes and draw attention to the need for precaution and appropriate treatment related to head trauma. Data from this study highlight the important reality that the majority of reported

patients with sports-related TBI that present to an ED are middle school and high school-age athletes.

After controlling for factors such as injury severity and age, females were significantly less likely to be admitted to inpatient care than their male counterparts perhaps reflecting clinically important gender-related differences in injury severity which were not fully captured in the anatomy-based AIS scores. Interestingly, substantial variability in the odds of admission to inpatient care was apparent across geographic regions. It is possible that region-related variability in the types of sporting activity a patient was engaged in at the time of injury might drive this relationship and further research is warranted to examine differences in severity of head trauma associated with different injury across different sports; however, the possibility that inter-regional differences in sampling might bias our findings cannot be completely ruled out. The weight of parental influence among the younger age groups may have contributed to injury reporting in these children. However, stakeholders' concerted efforts to inform coaches, athletes, and families about the importance of recognizing TBI and the importance of seeking treatment may have contributed to the increase in ED presentation observed across all age groups. Over the six-year study period, the incidence of reported sports-related TBI rose significantly, again with the highest proportional increases being seen among middle and high-school age children.

The dramatic rise in annual ED presentations for sports-related TBI observed across the study period may be driven by increased emphasis on sports-related TBI prevention, recognition and treatment, especially among school-age children. While the number of ED visits related to such injuries is rising, the proportion of presenting cases admitted to the

hospital is falling with the actual number of individuals admitted to inpatient care remaining relatively stable. Of extreme importance is our finding that the vast majority of patients presenting with sports-related head trauma are of middle- and high-school age. Further research is warranted to understand relationships between TBI and long-term outcomes, especially among young athletes.

Citations:

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Table 1: Patient and injury characteristics

Characteristic	Male (%)	Female (%)	Total	p
Total	368,474 (75.6)	118,747 (24.4)	487,221	
Age				
<12 years	63,518 (81.6)	14,322 (18.4)	77,839	<.001
12-14 years	92,531 (75.2)	30,593 (24.8)	123,124	
15-18 years	146,868 (75.0)	49,079 (25.0)	195,947	
19-23 years	28,841 (74.1)	10,073 (25.9)	38,914	
> 24 years	36,715 (71.4)	14,681 (28.6)	51,397	
Insurance				
Government Insurance	53,306 (79.4)	13,867 (20.6)	67,173	<.001
Private Insurance	271,123 (74.4)	93,184 (25.6)	364,307	
Self-pay	27,417 (81.1)	6,401 (18.9)	33,818	
Other	14,992 (76.3)	4,664 (23.7)	19,656	
Missing data	1,636 (72.1)	631 (27.9)	2,267	
Admitted to hospital	15,154 (83.1)	3,079 (16.9)	18,233	<.001
Head AIS Score				
1	40,348 (81.3)	9,282 (18.7)	49,630	<.001
2	313,423 (74.6)	106,920 (25.4)	420,343	
3	11,470 (84.6)	2,094 (15.4)	13,564	
4	3,105 (87.7)	437 (12.3)	3,541	
5	128 (90.0)	14 (10.0)	142	
Hospital Region				
Northeast	97,470 (73.0)	36,027 (27.0)	133,497	<.001
Midwest	93,415 (76.1)	29,331 (23.9)	122,746	
South	100,837 (77.6)	29,068 (22.4)	129,905	
West	76,752 (75.9)	24,321 (24.1)	101,073	

Table 2: Logistic regression for inpatient hospital admission, adjusted for all other variables.

<i>Descriptor</i>	<i>Odds Ratio</i>	<i>p</i>	<i>95% Confidence Interval</i>		
Sex					
<i>Male</i>	(ref)	(ref)	(ref)	(ref)	
<i>Female</i>	0.79	<.001	0.72	0.87	
Age					
<i>< 12 years</i>	0.94	0.513	0.80	1.12	
<i>12-14 years</i>	0.81	0.008	0.70	0.95	
<i>15-18 years</i>	0.85	0.015	0.74	0.97	
<i>19-23 years</i>	0.77	0.001	0.66	0.90	
<i>> 24 years</i>	(ref)	(ref)	(ref)	(ref)	
Primary payer					
<i>Private insurance</i>	(ref)	(ref)	(ref)	(ref)	
<i>Government insurance</i>	1.12	0.094	0.98	1.29	
<i>Self-pay</i>	0.91	0.320	0.75	1.10	
<i>Other</i>	1.34	0.002	1.12	1.60	
<i>Missing data</i>	0.61	0.290	0.24	1.53	
Hospital region					
<i>Northeast</i>	(ref)	(ref)	(ref)	(ref)	
<i>Midwest</i>	1.38	0.016	1.06	1.79	
<i>South</i>	1.04	0.732	0.84	1.29	
<i>West</i>	1.39	0.004	1.11	1.75	
Head AIS score					
<i>1</i>	(ref)	(ref)	(ref)	(ref)	
<i>2</i>	0.40	<.001	0.35	0.46	
<i>3</i>	12.22	<.001	10.50	14.23	
<i>4</i>	60.71	<.001	47.51	77.58	
<i>5</i>	21.46	<.001	9.93	46.40	

Table 3. Sports-related TBI by age and year

	2006	2007	2008	2009	2010	2011	Total
Number of TBI							
<i>< 12 years</i> (%)	9,840 (15.5)	10,381 (16.0)	11,015 (15.7)	15,213 (16.8)	14,497 (15.6)	16,894 (16.0)	77,839 (16.0)
<i>12-15 years</i> (%)	15,106 (23.8)	15,319 (23.6)	17,239 (24.6)	21,839 (24.1)	24,187 (26.1)	29,434 (27.9)	123,124 (25.3)
<i>15-18 years</i> (%)	26,558 (41.8)	27,162 (41.8)	28,705 (40.9)	35,670 (39.4)	36,793 (39.7)	41,059 (39.0)	195,947 (40.2)
<i>18-24 years</i> (%)	5,096 (8.0)	5,228 (8.0)	5,813 (8.3)	7,435 (8.2)	7,279 (7.9)	8,063 (7.7)	38,914 (8.0)
<i>> 24 years</i> (%)	6,916 (10.9)	6,891 (10.6)	7,342 (10.5)	10,343 (11.4)	9,971 (10.8)	9,933 (9.4)	51,397 (10.5)
Total	63,516	64,981	70,114	90,499*	92,727	105,384*	487,221
Age-specific rate (per 100,000 in age range)							
<i>< 12 years</i>	20.5	21.6	22.7	31.3	29.7	34.6	26.8
<i>12-15 years</i>	119.7	122.6	138.8	176.3	195.0	237.0	164.7
<i>15-18 years</i>	152.2	153.9	161.6	201.0	208.7	237.2	185.7
<i>18-24 years</i>	24.1	24.6	27.2	34.5	33.6	36.6	30.1
<i>> 24 years</i>	3.5	3.4	3.6	5.0	4.8	4.7	4.2
Total	21.3	21.6	23.0	29.5	30.0	33.8	

*represents a statistically significant increase over the prior year total