Published in final edited form as:
J Pediatr. 2010 December ; 157(6): 889–893. doi:10.1016/j.jpeds.2010.06.040.

Pediatric Concussions in United States Emergency Departments in the Years 2002-2006

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Abstract

Objectives—To estimate the incidence and demographics of concussions in children coming to emergency departments (EDs) in the United States and describe the rates of neuroimaging and follow-up instructions in these patients.

Study design—This is a cross-sectional study of children 0-19 years old diagnosed with concussion from the National Hospital Ambulatory Medical Care Survey (NHAMCS). NHAMCS collects data on approximately 25,000 visits annually to 600 randomly-selected hospital emergency and outpatient departments. We examined visits to United States emergency departments between 2002 and 2006. Simple descriptive statistics were used.

Results—Of the 50,835 pediatric visits in the 5 year sample, 230 observations, representing 144,000 visits annually, were for concussions. Sixty-nine percent of concussion visits were by males. Thirty percent were sports-related. Sixty nine percent of patients diagnosed with a concussion had head imaging. Twenty-eight percent of patients were discharged without specific instructions to follow-up with an out-patient provider for further management.

Conclusions—Approximately 144,000 pediatric patients present to emergency departments each year with a concussion. Most of these patients undergo computed tomography of the head and nearly one third are discharged without specific instructions to follow-up with an out-patient provider for further management.

Keywords

Concussion; Mild Traumatic Brain Injury; Head Injury; Trauma; Injury; Sports

The epidemiology of concussion has been studied in various sports,(1,2) in athletes of particular ages,(3) and in other recreational activities.(4) Thurman et al reviewed the epidemiology of sport-related brain injuries assessed by several population based databases. Using data from the National Electronic Injury Surveillance System, they reported an estimated 216,000 sport

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and recreation-related head injuries (all head injuries, not only concussions) annually.(5) Based on data from the National Health Interview Survey, Sosin et al reported that 1.54 million American civilians sustained a brain injury with loss of consciousness annually, and that 20 % of these were secondary to sports.(6) The CDC estimates that 1.4 million traumatic brain injuries annually result in death, hospitalization or emergency department visits.(7). The epidemiology of head injuries, often including concussions, has been studied by various methods, including searches of the National Hospital Ambulatory Medical Care Survey (NHAMCS) database.(8,9) However, the study of the epidemiology of concussion has often been obfuscated by the confusion between the terms “concussion” and “mild traumatic brain injury.” Although several definitions exist for each term, consensus on a standard definitions has been difficult to reach. Often, “mild traumatic brain injury” is defined by Glasgow coma scale score.(10) Recently, “concussion” has been defined as a “a complex pathophysiological process affecting the brain, induced by traumatic biomechanical forces.”(11) As the signs, symptoms, and duration of concussive brain injury are often not considered “mild” by the patients experiencing them, the term “concussion” will be used throughout this manuscript.

This study used the NHAMCS database to examine the characteristics of children diagnosed with “concussion” separate and distinct from other forms of traumatic brain injury (e.g. skull fracture; intracranial injury of other and unspecified nature; hemorrhage; other brain injury; and head injury, unspecified). Further understanding of the epidemiology and trends in management of concussion in children may lead to targeted interventions in prevention, emergency care and follow up strategies.

METHODS

We examined emergency department (ED) visits in the NHAMCS database for the years 2002–2006. Administered by the United States Census Bureau, the NHAMCS is an annual survey of hospital ED and outpatient department visits, designed by the National Center for Health Statistics, a Division of the Centers for Disease Control and Prevention. A nationally representative sample of non-institutional, general (medical, surgical, and children's) and short-stay hospitals are randomly selected within geographically defined areas (Primary Sampling Units) after adjustment for size. Data are obtained from samples of geographically defined areas, hospitals within these areas, clinics and EDs within these hospitals, and patient visits within these clinics and EDs, as components of the 4-stage probability design. Visit information is collected during a randomly assigned 4-week reporting period each year by trained staff members at the sampled hospitals with monitoring by NHAMCS field representatives. Data consistency is ensured by processing at a central facility followed by manual checking using a computerized algorithm. Data are collected on approximately 25,000 visits annually to some 600 hospital EDs and outpatient departments. These data are then utilized to derive national estimates.

The NHAMCS dataset is publicly available via the Internet. This study was declared exempt from review by the institutional review board because data are publicly available and de-identified.

In the NHAMCS database up to three diagnoses are recorded as free text for each visit and then centrally coded using the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) codes. We identified patient visits for concussion in children aged 0 to 19 years using the ICD-9-CM codes for concussion (850.0, 850.1, 850.11, 850.12, 850.2, 850.3, 850.4, 850.5, 850.9).

Although we did examine the ICD-9-CM codes for skull fracture 800.xx-804.xx, head injury, unspecified 959.01, intracranial hemorrhage (851xx to 853xx), other brain injury (854xx) and intracranial injury of other and unspecified nature 854.xx, patients with these diagnoses alone were not included in the analyses of concussion. Our goal was to study concussion in the absence of structural brain injury. Similarly, we could not be sure that patients with some of these diagnoses alone had signs or symptoms of concussion. For example, pediatric patients who are evaluated after a blow to the head, such as toddlers who fall down the stairs, might be diagnosed with "head injury, unspecified 959.01" even if well appearing and symptom free. As we could not be sure that these patients had concussive symptoms, they were excluded. However, patients who were diagnosed with head injury, unspecified 959.01, skull fracture 800.xx-804.xx, or intracranial injury of other and unspecified nature 854.xx, who were also diagnosed with concussion 850.xx were included. We decided *a priori* to exclude patients diagnosed with concussion and an intracranial hemorrhage, as the signs and symptoms attributable to the hemorrhage would be difficult to distinguish from those attributable to a concurrent concussion. Those diagnosed with concussion and associated non-head injuries (e.g. radius fracture) were included in our analysis.

Facilities are indicated only by a pseudo-identifier in NHAMCS and we therefore used characteristics of the visits to categorize the types of hospitals. Academic hospitals were defined as facilities in which at least 25% of the patients were evaluated by a resident physician. EDs in which 90% or more of all visits (i.e., not only those for head injury) were for patients 19 years of age or younger were classified as pediatric facilities. We examined data on other hospital characteristics including region (Northeast, South, Midwest, and West) and setting (urban and rural).

In addition to type of hospital, we examined the following data: injury intent (unintentional, intentional and unknown), discharge diagnoses, patient demographics (age, sex, race, and ethnicity), use of computed tomography (CT) or magnetic resonance imaging (MRI), patient insurance type (private, Medicaid, self-pay and other), ED visit within prior 72 hours, patient disposition (discharge vs. hospital admission) and whether or not instructions were given to follow-up for further out-patient management. Patient race (White, Black, Asian/Pacific Islander, Native American, other, multiple) and ethnicity (Hispanic or non-Hispanic) were determined based on the observations of hospital personnel, unless it is hospital policy to ask patients directly for this information. This is in accordance with the NHAMCS instructions to record race and ethnicity according to the "hospital's usual practice or based on your knowledge of the patient or from information in the medical record."

In addition, we created an "associated injuries" variable, defined as the presence of any non-concussion or head injury ICD-9-CM code in the diagnoses. We categorized mechanisms of injury by using the Centers for Disease Control and Prevention-recommended framework for presenting injury morbidity data (12) and prior grouping schemes described by Bazarian et al including: 'Motor vehicle trauma' (E800–E807), motor vehicle traffic accidents (E810–E819), motor vehicle non-traffic accidents (E820–E825) and accidents involving other vehicles not elsewhere classifiable (E848); 'sports injuries' included falls during sports (E886.0), accidentally being struck during sports (E917.0) and injuries involving horses (E828).(13) In addition, we reviewed the patient's verbatim report of cause of injury for each observation to double check the classification scheme.

We collected data regarding the use of CT or MRI, which was available for the years 2003-2006. The NHAMCS case report form indicates only whether CT or MRI was performed. It does not specify the body part imaged. Using the analysis described by Blackwell et al in a prior study of CT utilization, imaging was assumed to be of the head, as the ultimate diagnosis of included patients was "concussion."(14) In order to ensure our results were not confounded by imaging of other body parts, the proportion of patients imaged was recalculated after removing admitted patients and those with associated injuries, as these patients were the most likely to have imaging of a body part other than the head.

The NHAMCS case report form directly queries whether or not follow-up for the patient is recommended. Those entries marked "return/refer to physician/clinic for FU" or "follow up with other MD" were categorized as given specific instructions to follow-up, regardless if "return if needed, PRN/appointment" was also checked. All other patients, including those with either "no follow-up planned" or "return if needed, PRN/appointment," without the specific instructions described previously, were categorized as not given specific instructions to follow-up.

Weights, strata, and primary sampling unit design variables provided by the NHAMCS were used for all analyses. We used descriptive statistics, with appropriate weighting, to account for the survey sampling methodology, using the *svy* commands available in Stata 10.1 (StataCorp, College Station, TX). Per NHAMCS recommendations, only those queries with at least 30 observations recorded were included in analyses.

RESULTS

Of the 183,520 observed ED visits in the pooled five-year sample, 28% (95% CI 26.7, 28.8) were for children 19 years or younger. This represents 158,000,000 pediatric ED visits nationally, over the five years of study. Of the observed pediatric ED visits, 1256 observations (2.5%; 95% CI 2.2, 2.7) were for head injury, representing 3,890,996 visits. Of those diagnosed with head injury, 1.3% (95% CI 0.61, 2.6) were ultimately diagnosed with intracranial hemorrhage. Eighteen percent (95% CI 18, 22) were diagnosed with concussion, representing 720,000 visits in the 5 year sample; 144,000 visits annually. Forty percent of all patients diagnosed with concussion were between the ages of 15 and19 years. Thirty percent of all pediatric concussions were related to sports activity. For adolescents (aged 11-19 years), the percentage of concussions related to sports activity was much greater (41%) than for younger children (8%). Sixty nine percent of patients diagnosed with a concussion had imaging performed. This was almost exclusively CT. Unfortunately, data regarding the mode of imaging was unavailable for the years 2002-2003. For the remaining years, however, all patients diagnosed with a concussion who underwent imaging had a CT; none had an MRI. Removing patients who were most likely to have other body parts imaged (admitted patients and those with associated injuries) did not alter the proportion of imaged patients. Nearly 5% of patients were admitted. Twenty-eight percent of discharged patients were not given instructions to follow-up with an out-patient provider. Further demographics for the study population are shown in the Table.

DISCUSSION

Over the last several years, the diagnosis of concussion has received increased amounts of attention in the lay media(15-18) as well as medical literature,(19-22) with more medical publications over the last 9 years than all the previous years combined.(22) Still, relatively little is known about this diagnosis. The rates of this injury in the overall pediatric population presenting to emergency departments has not been previously reported.

Our data suggest that 1 out of every 220 pediatric patients seen in emergency departments is diagnosed with a concussion. On a national level, this represents approximately 144,000 visits annually. As with other studies,(4) more concussions in our study were seen in males than females. Although 40% occurred in high school aged patients (15-19 years old), concussions among elementary and junior high school children accounted for 42%.

Our analysis shows that imaging, almost exclusively CT, is frequently employed to rule out structural injury when making the diagnosis of concussion. The risk of radiation associated with CT has become a concern,(23) especially in pediatric patients.(24) Recent studies have attempted to reduce unnecessary CT in the setting of head trauma.(25-27) Despite this trend, 69% of patients in our study had imaging of the head, suggesting that emergency department physicians are relying heavily on imaging to exclude structural intracranial injury when making the diagnosis of concussion. This is an area where improvement might be made.

Twenty-eight percent of children were not given instructions to follow-up with an outpatient provider. As the main focus of emergency department care is to assess and treat emergent and urgent issues, discussions involving long-term care plans, expectations, and detailed recovery patterns are not expected. These issues are more properly addressed during follow-up visits. However, many patients with concussion being discharged from EDs, or hospitals after admission are not given proper follow-up instructions.(28) This is significant, as one of the few, proven, effective interventions in the management of concussion is early education regarding common symptoms, likely time course, and coping strategies.(29) Similarly, lengthy discussions regarding the role of cognitive rest and physical rest in recovery, the risks of cognitive effects, impact on academic performance, and risks of recurrent injury, are unlikely to occur in the ED. Recovery times vary considerably, with pediatric patients requiring longer to recover from concussion than older patients.(30) Previous studies suggest that even with instructions to follow-up, compliance is poor.(31) Targeted strategies may improve performance in this area.

It is recommended that decisions regarding safe return to athletics not be made in the acute setting, as symptoms can have a delayed onset, and characteristics of the acute injury, such as loss of consciousness, do not consistently predict recovery.(32,33) The ED provider cannot accurately predict how long it will take for a given patient to recover, or when a given patient will be ready to resume their previous activities. Furthermore, neuropsychological testing has proven highly valuable in the assessment and management of concussive brain injury. In fact, it has been referred to as “one of the cornerstones of concussion evaluation.”(34,35) This is not undertaken in the emergency department, but rather, specialty clinics for concussive brain injury. This further underscores the need for appropriate follow-up.

Sport participation was the most common mechanism of concussion, accounting for 30% of all diagnosed concussions. This percentage is slightly larger than that reported by Sosin, et al who found that 20% of all civilian head injuries resulting in a loss of consciousness, but not resulting in death or long term institutionalization, occurred during sports.(6) As most concussions in sports do not involve a loss of consciousness(36-38), this discrepancy is not surprising. Because sports activity is the most common mechanism for concussion, and injured athletes often return to the activity which placed them at risk for concussion, efforts focusing on the prevention, proper assessment and proper management of sport-related concussion could have a significant impact.

This study has several limitations. First, it represents a cross-sectional analysis of previously collected data. Although the multistage sampling techniques of the NHAMCS database are designed to make the sample representative of the entire United States, the number of observations was limited, and in a few cases fell below the threshold number of observations (30) recommended for analysis. Second, the database does not provide information on which body part was imaged. It only reports whether computed tomography or magnetic resonance imaging was performed. However, using the analysis described by Blackwell et al, we based our case definition on ICD-9-CM codes for concussion and, therefore, assumed imaging to be head imaging.(14) Moreover, removing patients who were most likely to have other types of CT or magnetic resonance imaging did not alter the proportion of imaged patients. Finally, our results are likely an underestimate of the number of concussions seen in United States EDs. Given the lack of consensus on the definition of concussion, many patients with concussion may have received the ICD-9-CM codes for other injuries such as, intracranial injury of other and unspecified nature (854.xx), head injury, unspecified (959.01), or skull fracture (800.xx-804.xx). Furthermore, many clinicians may only consider the diagnosis of concussion when brain injury is associated with a loss of consciousness.(19) Therefore, patients who did not lose consciousness at the time of their concussion would not have been included. These were intentionally excluded to generate a conservative estimate, avoiding patients with structural intracranial injuries or children evaluated for trauma to the head, without any signs or symptoms of concussion.

Acknowledgments

Supported by the NIH through the Children's Hospital Child Health Research Center Award to R.M. (K12 HD052896-01A1) and T32 Award to W.M. (T32 HD040128-06A1). The authors declare no conflicts of interest.

Abbreviations

NHAMCS	National Hospital Ambulatory Medical Care Survey
ED	Emergency Department
CT	Computed Tomography
MRI	Magnetic Resonance Imaging

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Table 1

Characteristics of pediatric patients with concussions recorded in NHAMCS for the years 2002-2006.

		Number of Observations (n=230)	Estimated Percent Patient Encounters (%)*
Age	< 1 year	7	4
	1-4 years	31	15
	5-9	34	14
	10-14	64	28
	15-19	94	40
Sex	Male	154	69
	Female	76	31
Race	White	197	84
	Non-White	33	16
Ethnicity	Hispanic	29	9
	Non-Hispanic	191	88
	Unknown	10	3
Insurance Type	Private	135	58
	Medicaid	43	21
	Self	26	8
	All others	26	13
Geographic Location	Northeast		19
	South	70	38
	Midwest	47	22
	West	59	21
	Metropolitan	191	80
	Non-Metropolitan	39	20
Type of Institution	Teaching Hospital	25	8
	Non-Teaching	205	92
	Pediatric Hospital	17	6
	Non-Pediatric Hospital	213	94
Mechanism of concussion	MVC	40	20
	Bicycle-related	11	6
	Hit by Car	4	2
	Sport	70	30
	Fall from Height	24	9
	Fall on Stairs	2	2
	Fall from Standing	21	9
	Assault	9	4
	Other	34	13
	Unknown/Missing	15	5
Clinical Characteristics	Additional Head Injuries	41	18
	Additional Injuries	29	14
Clinical Decisions	Head Imaging Obtained	154	69

		Number of Observations (n=230)	Estimated Percent Patient Encounters (%)*
	Admitted to the Hospital	14	5

*Percent patient encounter calculated by survey-weighted methodology