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Youth Motorcycle-Related Hospitalizations and Traumatic Brain Injuries in the United States, 2006

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Introduction

According to the National Highway Traffic Safety Administration, in 2009 motorcyclists of all ages were about 25 times more likely than passenger car occupants to die in a motor vehicle traffic crash and 5 times more likely to be injured per vehicle mile traveled. In 2009, motorcyclists accounted for a record 13% of all traffic fatalities (National Center for Statistics and Analysis, n.d.). The Centers for Disease Control and Prevention (CDC) reported that for the period 1999-2003 the fatality risk on a person-trip basis was 58 times greater for motorcycles than passenger vehicles (Beck, Dellinger, & O'Neil, 2007). Due to increased use of motorcycles for recreation, their appeal as a fuel-saving travel mode, and because of repeals of State universal helmet laws the numbers of motorcycle deaths and injuries rose between 1997 and 2008, before declining slightly in 2009 (Coben, Steiner, & Miller, 2007; National Center for Statistics and Analysis, n.d.).

Unfortunately, these trends also hold for young adults and children. The CDC reports that the motorcyclist death rate for the 12-to-20 age group was 0.52 per 100,000 population in 1999 and increased to 0.99 per 100,000 population in 2007, the last year of available data, representing an 90% increase (Centers for Disease Control and Prevention—WISQARS (Web-based Injury Statistics Query and Reporting System). In a recent review of trends in hospitalized traumatic brain injury (TBI) from a national sample, Bowman, Bird, Aitken, and Tilford reported a significant increase in teenage male TBI hospitalization rates from 1998 to 2005 for motorcycle crashes, one of the very few mechanisms for TBI showing an increase over the study period (Bowman, Bird, Aitken, & Tilford, 2008).

This paper describes more fully and compares the national burden of motorcycle injuries and motorcycle-related TBIs in both traffic and nontraffic domains. This study also discusses in detail the burden of TBI, not only in terms of narrower age specific incidence, but in terms of charges, costs, and long-term outcomes that have not been reported in this level of detail for motorcycle injured youth in a nationally representative dataset. A shorter version of this study has been published in the December 2010 issue of the journal *Pediatrics* volume 126(6) pages 1141-8.

Methods

For our study, retrospective data were obtained from the 2006 Kids' Inpatient Database (KID) developed as part of the Healthcare Cost and Utilization Project (HCUP) sponsored by the Agency for Healthcare Research and Quality (AHRQ). The University of Pittsburgh Institutional Review Board categorized this as an exempt study since it used an unlinked public database without individual identifiers.

The KID contains both patient (demographics and clinical data) and hospital-level data. The 2006 KID includes data drawn from 38 State hospital inpatient databases for children 20 and younger from 3,739 community non-rehabilitation, non-Federal hospitals. The sample contains 3,131,324 unweighted pediatric discharges (Agency for Healthcare Research and Quality, 2008). Systematic random sampling was used by AHRQ to construct the KID by selecting 10% of uncomplicated births, and 80% of complicated pediatric cases, including complicated births, from each hospital in the sampling frame (Agency for Healthcare Research and Quality, 2008). For national estimates, the data are weighted and most analyses reported in this paper (except where indicated) are weighted estimates. Analyses were performed using the survey analysis options in the software Stata 10.0 (from StataCorp LP, College Station, TX) and SAS 9.1 (from SAS Institute Inc., Cary, NC). Incidence rate calculations utilized single year intercensal U.S. population estimates

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for 2006 (United States Department of Health and Human Services (US DHHS) Centers for Disease Control and Prevention (CDC)).

Cases were first selected for ages 12 to 20. We used this 9-year age range, unlike most studies that examine youth in 5-year age groups up to age 19, because many State motorcycle helmet laws require youth 20 and younger to wear helmets even when people 21 and older are exempt from helmet requirements. The lower age bound was chosen because of the sharp rise in incidence observed for cases beginning at age 12 and because below age 12 the cell sizes were often too small to analyze. There were 1,731,062 weighted discharges for youth 12 to 20 years old.

Motorcycle injuries were selected on the basis of International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) E-code matrix groupings (E810-E819, traffic) and (E820-E825, non-traffic) with a fourth digit of .2 indicating a motorcyclist or .3 indicating a motorcycle passenger. Analyses were done on the combined population of drivers and passengers, hereafter referred to as riders. Although predominately made up of typical street-registered motorcycles, these ICD codes can also include motorized bicycles (mopeds), scooters, and mini-bikes that may or may not be registered in different States. "Traffic" crashes are those that occurred on a public highway. By ICD coding guidelines, a motor vehicle crash is assumed to have occurred on the highway unless another place is specified, except in the case of crashes involving only off-road motor vehicles, which are classified as non-traffic crashes. These codes exclude off-road vehicles that are not motorcycles, such as ATVs that have been described by others for 1997 and 2000 versions of the KID (Killingsworth et al., 2005). Two cases with ambiguous traffic status because of a separate E-code within each traffic category were set to missing traffic status and one case with an E820.2 (indicating a non-traffic crash involving a motor-driven snow vehicle as a motorcyclist) was dropped. The core patient discharge file was merged with the hospital file to include hospital characteristics for each case. Diagnoses and procedures were grouped using the Clinical Classifications Software (CCS) for ICD-9-CM. CCS combines individual ICD-9-CM diagnosis and procedure codes into broader diagnosis and procedure categories (Agency for Healthcare Research and Quality).

Traumatic brain injury was defined and selected on the basis of a TBI-related diagnoses in any of the first 10 diagnosis fields in accordance with ICD codes specified by the CDC TBI surveillance case definition (Butler & A., 2001). The CDC TBI case definition includes ICD-9-CM diagnosis codes 800.0-801.9, 803.0-804.9, and 850.0-854.1. The code 959.01 (head injury unspecified), which was added later to the initial CDC case definition, was also included. The TBI codes with late effects and complications (905.0 and 907.0) were excluded. TBI cases were also grouped according to the Barell body region by nature of injury diagnosis matrix, 2002 update (National Center for Health Statistics). Estimates for TBI-related long-term disability were computed from regression coefficients and programming provided by Selassie et al. based on their previously published modeling approach (Selassie et al., 2008). Disability was defined in their model as "having 1 or more of the following: (a) functional limitation in at least 1 of the ADLs (activities of daily living); (b) significant post-injury symptoms that limited activities; (c) significant cognitive complaints, that is, scores that were 2 SDs above the population norm (≥22.2); or (d) significant problems in mental health, that is, scores that were 2 SDs below the population norm (≤30)"(Selassie et al., 2008). A detailed description of the approach used to develop the probability model for long-term disability can be found in the study by Selassie et al (Selassie et al., 2008). Injury severity was calculated using the algorithms of the ICD Programs for Injury Categorization (ICDPIC) provided by the American College of Surgeons, which translates ICD diagnosis codes into "abbreviated injury scores" (AIS) and "injury severity scores" (ISS) (Clark, Hahn, & Osler, 2008).

Because our primary aim was to measure the overall burden of injury, for most analyses we included all cases regardless of discharge status in the database because we wanted to capture the costs of multiple admissions. However, for the incidence and long-term disability estimates, in order to avoid duplicate counts because of hospital transfers, patients who were discharged to another short-term care facility were excluded, consistent with the approach of other population-based hospitalization studies (Bowman et al., 2008). Cost-to-charge ratios were used to estimate the actual hospital medical costs, in addition to hospital charges, the latter of which only represent the billing amounts and not the reimbursements costs actually received.

Using these definitions, among youth 12 to 20 there were a total of 186,734 injuries with a mechanism specified (all types) and among all types 34,779 (18.6%) were TBI-related. From these discharges the motorcycle-related cases were subsetted and examined.

Results

The national population estimate for all motorcycle-related hospital discharges for the age group 12 to 20 in 2006 was 5,662 (95% CI, 5,201-6,122) (Table 1) representing 3.0% of all injuries in this age group. Seven percent (95% CI = 6.3%-7.5%) of the weighted, motorcycle-related discharges were reported as motorcycle passengers. Males were predominant, comprising almost 90% of the discharges. About half the cases were in the 18-to-20 age group (50.2%, 95% CI = 47.9%-52.4%), followed by the 15- to 17-year-olds (31.7%, 95% CI = 30.1%-33.4%) and the 12- to 14-year-olds (18.1%, 95% CI = 16.3%-19.8%). Most patients were routinely discharged home (82.9%, 95% CI = 81.4%-84.5%) but 6.1% (95%

Table 1
Patient characteristics and disposition for youth motorcycle-related hospitalizations, 2006

Characteristics	n (95% CI)	% (95% CI)
Total estimated number of cases	5,662 (5,201-6,122)	
Event location		
Traffic	3,839 (3,512-4,167)	67.8 (65.2-70.4)
Non-traffic	1,822 (1,735-1,909)	32.1 (29.5-34.8)
Gender		
Male	5,016 (4,609-5,424)	89.7 (88.7-90.8)
Female	575 (460-653)	10.3 (9.2-11.3)
Age group (years)		
12-14	1,023 (887-1159)	18.1 (16.3-19.8)
15-17	1,797 (1622-1972)	31.7 (30.1-33.4)
18-20	2,840 (2590-3093)	50.2 (47.9-52.4)
Median income of patient's ZIP Code (dollars)		
1 – 37,999	1,343 (1172-1513)	24.4 (22.0-26.7)
38,000 – 46,999	1,313 (1174-1452)	23.8 (22.1-25.5)
47,000 – 61,999	1,481 (1336-1627)	26.8 (25.1-28.6)
62,000+	1,372 (1199-1546)	24.9 (22.7-27.1)
Disposition of patient		
Routine (home)	4,697 (4,318-5,076)	82.9 (81.4-84.5)
Transfer: short-term hospital	139 (103-175)	2.4 (1.9-3.0)
Transfer: other type of facility	345 (283-407)	6.1 (5.2-6.9)
Home health care	360 (295-425)	6.4 (5.3-7.4)
Against medical advice	27 (15-40)	0.5 (0.3-0.7)
Died	91 (63.5-119.1)	1.6 (1.15-2.1)

CI – confidence interval.

CI = 5.2%-6.9%) were transferred to rehabilitation or skilled nursing facilities, and 1.6% (95% CI=1.2-2.1%) or 91 (weighted) cases died.

The leading principal diagnoses were fractures of the lower limb (29.2%, 95% CI=27.6%-30.8%), intracranial injury (17.0%, 95% CI= 15.7%-18.3%), crushing injury or internal injury (14.0%, 95% CI=12.8%-15.1%), and fractures of the upper limb (12.3%, 95% CI=11.1%-13.5%) (Table 2).

There were also 91 (95% CI=67-114) spinal cord injuries reported. Table 3 shows the facility characteristics, procedures, and payer. Only 4.4% (95% CI=2.9%-5.9%) of the discharges were from a freestanding children's hospital. Private insurance did not cover 35% of the cases.

Two-thirds of the discharges were traffic-related (67.8%, 95% CI = 65.2%-70.4%) with the 18- to 20-year-olds having the highest proportion of traffic-related discharges (82.1%, 95% CI = 74.7%-89.4%) and the 12- to 14-year-olds having the lowest (46.7%, 95% CI = 39.3%-54.1%) (not shown). Traffic-related injuries were generally more severe as evidenced by a higher length of stay, higher mean charges and costs, higher mean number of procedures, higher percentage of cases in the severe ISS category, greater likelihood of an intracranial injury diagnosis, and a higher inpatient mortality rate (Table 4).

With transfers to short-term-stay hospitals excluded to reduce double counting, the overall incidence rate of motor-

Table 2
Hospital charges and length of stay by diagnosis and hospital location status for all youth motorcycle-related discharges, 2006

			Hospital charges ($)			LOS (days)	
	n (95% CI)	% (95% CI)	Mean	Median	Total charges	Mean	Median
Number of cases (95% CI)	5662 (5201- 6122)		44,227	24,641	248,636,811	4.8	3.0
Top ten principal diagnoses							
Fracture of lower limb	1654 (1501-1806)	29.2 (27.6-30.8)	42,966	30,392	70,573,921	4.5	3.0
Intracranial injury	962 (848-1076)	17.0 (15.7-18.3)	60,728	24,555	58,148,971	6.6	2.0
Crushing injury or internal injury	791 (695-887)	14.0 (12.8-15.1)	44,397	22,029	34,773,855	5.4	3.0
Fracture of upper limb	697 (607-787)	12.3 (11.1-13.5)	30,068	21,360	20,914,212	2.9	2.0
Other fractures	389 (332-447)	6.9 (6.1-7.7)	46,284	23,906	17,828,648	4.9	3.0
Open wounds of extremities	226 (185-268)	4.0 (3.3-4.7)	32,515	18,259	7,255,835	4.4	2.0
Skull and face fractures	187 (149-224)	3.3 (2.7-3.9)	42,490	24,919	7,755,670	3.9	3.0
Other injuries and conditions	129 (99-159)	2.3 (1.8-2.8)	24,985	16,186	3,199,226	3.0	2.0
Spinal cord injury	91 (67-115)	1.6 (1.2-2.0)	153,209	106,713	13,956,188	14.4	7.0
Open wound of head/neck/trunk	84 (59-109)	1.5 (1.1-1.9)	23,201	14,422	1,947,721	2.9	2.0
Hospital location/teaching status							
Rural			16,440	12,957	6,861,742	2.7	2.7
Urban nonteaching			39,272	22,229	62,575,856	3.9	2.0
Urban teaching			50,004	27,764	172,552,505	5.5	5.5

CI – Confidence Interval

Table 3

Facility characteristics, procedures and expected payers for all youth motorcycle-related hospitalizations, 2006

Characteristics	N (95% CI)	% (95% CI)
Hospital location/teaching status		
Rural	412 (378-445)	7.5 (6.6-8.3)
Urban nonteaching	1,604 (1,415-1,793)	29.2 (25.8-32.4)
Urban teaching	3,480 (3,065-3,895)	63.3 (59.8-66.9)
Children's hospital status		
Not a children's Hospital	3,494 (3,177-3,812)	66.1 (60.1-71.9)
Freestanding children's general hospital	233 (152-315)	4.4 (2.9-5.9)
Children's unit in a general hospital	1,560 (1,164-1,956)	29.5 (23.5-35.4)
Top 10 principal procedures		
Tx, fracture/dislocation of lower extremity	800 (721-877)	18.4 (16.9-20.0)
Tx, fracture/ dislocation of hip and femur	743 (650-836)	17.1 (15.8-18.5)
Tx, fracture/ dislocation of radius and ulna	354 (298-409)	8.2 (7.1-9.3)
Debridement of wound	253 (208-297)	5.8 (4.9-6.8)
Other fracture and dislocation procedure	245 (203-287)	5.7 (4.8-6.5)
Suture of skin and subcutaneous tissue	242 (195-289)	5.6 (4.6-6.6)
Respiratory intubation and mechanical ventilation	150 (117-182)	3.4 (2.8-4.1)
Traction, splints/other wound care	102 (75-130)	2.7 (1.8-2.9)
Skin graft	86 (62.7-110.3)	2.0 (1.5-2.5)
Procedures on spleen	73 (50.5-96.1)	1.7 (1.2-2.2)
Primary expected payer		
Medicaid	958 (828-1087)	17.0 (15.2-18.7)
Private insurance	3,669 (3,343-3,996)	65.0 (62.8-67.2)
Self-pay	636 (549-723)	11.3 (9.9-12.6)
No charge	63 (38-88)	1.1 (0.7-1.5)
Other	314 (255-373)	5.6 (4.6-6.5)

CI – confidence interval.
Tx – treatment

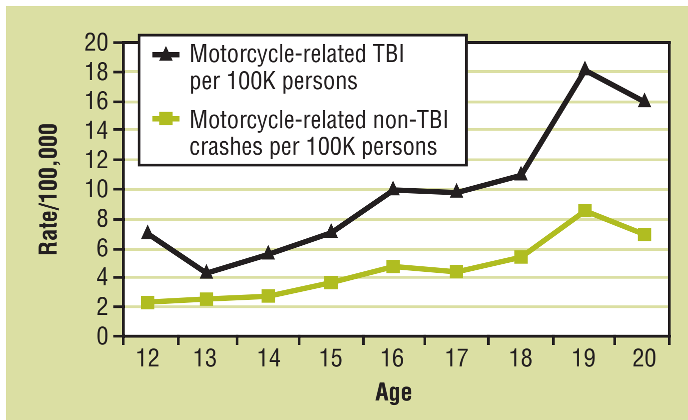
cycle-related discharges for youth 12 to 20 was 14.5 (95% CI 12.1-17.1) cases per 100,000 people. The overall TBI incidence rate was 4.6 (95% CI 3.7-5.5) per 100,000 people, increasing over age from 2.2 (95% CI 1.5-2.8) among 12-year-olds to 7.1 (95% CI 5.9-8.2) among 20-year-olds. The rate of non-traffic motorcycle crashes varied little by age, whereas the rate of traffic-related crashes began to rise at age 15 (5.7/100000 (95% CI 4.6-6.7) and continued rising to age 19 to 22.2/100,000 (95% CI 19.4-25.0) (not shown).

About one-third of the discharges involved a TBI diagnosis (31.7%, 95% CI=28.8%-34.5%) (Table 5). One-half of the TBI discharges were in the 18- to 20-year-old age group.

Figure 1 shows the distribution of TBI discharges by single year of age. The mean length of stay was over 2 days longer for TBI discharges, 6.3 versus 4.1 days. TBI discharges were 7% more likely to be traffic-related; 72.4% versus 65.7%. The charges and costs were significantly higher among TBI discharges. TBI-related discharges were twice as likely to be discharged to skilled nursing facilities, 5 times more likely to be discharged to other rehabilitation facilities, and over 8 times more likely to die in the hospital.

Figure 1

Motorcycle injury discharge incidence* rate by TBI status and age (per 100,000 people), 2006 (Rate per 100,000 people by age).

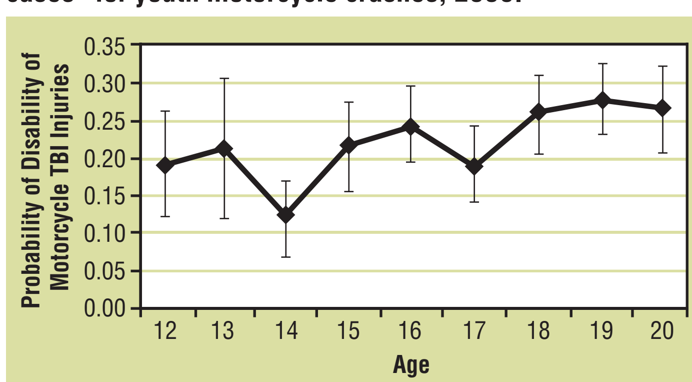


*Excludes patients who were discharged to another short-term care facility

The probability of long-term TBI-related disability among TBI cases by age is shown in Figure 2. The probability of long-term TBI-related disability among TBI cases was 0.24 overall (95% CI= 0.22-0.26) and 0.26 (95% CI=0.24-0.29) for traffic cases and 0.17 (95% CI=0.14-0.21) for non-traffic cases (not shown).

Figure 2

Probability by age of TBI-related disability among TBI cases* for youth motorcycle crashes, 2006.



*Excludes patients who were discharged to another short-term care facility, 95% CI shown.

Table 4
Description by crash location for all youth motorcycle-related hospitalizations, 2006

Characteristics	Traffic		Non-traffic	
	N (95% CI)	%	N (95% CI)	%
Number of Cases (95% CI)	3,839 (3,512-4,167)	67.8	1,822 (1,598-2,047)	32.2
Age (mean years)*	17.6		15.9	
Age				
12-14	478 (402-553)	12.4	545 (459-632)	29.9
15-17	1030 (921-1138)	26.8	767 (664-871)	42.1
18-20	2,332 (2,123-2,541)	60.7	509 (438-580)	27.9
Length of Stay (mean days)*	5.5		3.4	
Charges (mean dollars)*	$49,721		$32,627	
Cost (mean dollars)*	$18,275		$12,373	
Number of Procedures (mean)*	2.8		1.9	
Gender (% female)**				
Male	3,366 (3,091-3,642)	88.6	1,650 (1,471-1,829)	92.1
Female	434 (369-468)	11.4	141 (110-173)	7.9
ISS Score (mean)*	10.5		9.1	
ISS Score (% of total)				
Mild (ISS 0-8)	1,695 (1,563-1,826)	44.3	931 (828-1034)	51.2
Moderate (ISS 9-16)	1,354 (1,202-1,506)	35.4	685 (587-783)	37.645
Severe (17-75)	778 (668-888)	20.3	203 (158-249)	11.184
AIS Head Region Score				
AIS 1-2 Mild	748 (669-828)	52.6	349 (294-404)	63.9
AIS 3 Moderate	472 (402-542)	33.1	116 (90-141)	21.1
AIS 4-6 Severe	203 (165-240)	14.2	82 (57-107)	15.0
Top Five principal Diagnoses (% of total)				
Fracture of lower limb	1,114 (1,000-1,228)	29.0	540 (455-624)	29.6
Intracranial injury	719 (623-814)	18.7	243 (196-290)	13.3
Crushing injury or internal injury	463 (397-529)	12.1	328 (269-387)	18.0
Fracture of upper limb	440 (377-503)	11.5	257 (203-311)	14.1
Other fractures	255 (211-299)	6.6	135 (104-166)	7.4
Disposition (% of total)**				
Routine (home)	3,083 (2,825-3,341)	80.3	1,614 (1,415-1,814)	88.6
Transfer: short-term hospital	96 (69-122)	2.5	44 (24-63)	2.4
Transfer: other type of facility	278 (221-336)	7.2	66 (46-87)	3.6
Against medical advice	23 (12-35)	0.6	<10	0.2
Home health care	276 (225-328)	7.2	84 (53-114)	4.6
Died in hospital	91 (55-108)	2.1	10 (2-18)	0.5
Fatality**				
Nonfatal	37,58 (3441-4076)	97.9	1,812 (1589-2036)	99.5
Fatal	81 (55-108)	2.1	10 (2-18)	0.5
Payer (% of total)**				
Medicare	<10	0.1	<10	0.1
Medicaid	718 (609-827)	18.8	239 (190-289)	13.2
Private	2,330 (2,112 – 2,547)	60.9	1,340 (1,164-1,515)	73.6
Self-pay	490 (412-567)	12.8	146 (114-179)	8.0
No charge	48 (27-69)	1.3	15 (2-28)	0.8
Other	236 (188-283)	6.2	78 (52-105)	4.3
Hospital location/teaching status (% of total)**				
Rural	240 (219-260)	6.4	172 (154-190)	9.8
Urban, nonteaching	1026 (913-1139)	27.4	578 (481-674)	32.9
Urban, teaching	2,475 (2,185-2,764)	66.2	1,005 (834-1,176)	57.3

*t-test: $p<0.0001$
**Chi-square test: $p<0.0001$
CI – confidence interval

Table 5

Characteristics of motorcycle-related traumatic brain injury for all youth motorcycle-related hospitalizations in the United States, 2006.

Characteristics	TBI		Non-TBI	
	N (95% CI)	%	N (95% CI)	%
Number of Cases (95% CI)	1,793 (1,631-1,955)	31.7	3,869 (3,560-4,178)	68.3
Age (mean years)	17.1		17.0	
12-14	298 (244-352)	16.6	725 (627-823)	18.7
15-17	583 (509-657)	32.5	1,214 (1,088-1,340)	31.4
18-20	911 (811-1,012)	50.8	1,930 (1,759-2,100)	49.9
Length of Stay (mean days)*	6.3		4.1	
Charges (mean dollars)*	$58,444		$37,642	
Cost (mean dollars)*	$21,216		$14,137	
Number of Procedures (mean)*	2.9		2.4	
Crash Location**				
Traffic	1,297 (1,143-1,451)	72.4	2,542 (,2320-2,764)	65.7
Non-Traffic	495 (412-579)	27.6	1,327 (1,157-1,496)	34.3
Gender (% female)***				
Male	1,577 (1,405-1,749)	88.2	3,439 (3,158-3,721)	90.4
Female	210 (168-252)	11.8	365 (306-423)	9.6
ISS Score (mean)*	14.1		8.2	
Mild (ISS 0-8)	454 (392-515)	25.3	2,172 (2,005-2,339)	56.4
Moderate (ISS 9-16)	694 (615-773)	38.7	1,345 (1,193-1,497)	34.9
Severe (17-75)	645 (561-729)	36.0	337 (227-396)	8.7
AIS Head Region Score				
AIS 1-2 Mild	950 (842-1059)	53.0	147 (133-162)	83.3
AIS 3 Moderate	577 (499-654)	32.2	11 (3-18)	6.0
AIS 4-6 Severe	266 (217-314)	14.8	19 (9-29)	10.7
Disposition (% of total)**				
Routine (home)	1,355 (1,204-1,506)	75.6	3,342 (3,065-3,620)	86.4
Transfer: short-term hospital	55 (34-76)	3.1	84 (57-112)	2.2
Transfer: other type of facility	216 (169-263)	12.1	129 (99-158)	3.3
Against medical advice	11 (3-19)	0.6	11 (7-27)	0.4
Home health care	79 (53-106)	4.4	281 (226-335)	7.3
Died in hospital	75 (50-100)	4.2	16 (6-25)	0.4
Fatality**				
Nonfatal	1,717 (1,529-1,906)	95.8	3,853 (3,537-4,169)	99.6
Fatal	75 (51-100)	4.2	16 (6-27)	0.4
Payer (% of total)				
Medicare	< 10	0.1	<10	0.1
Medicaid	311 (256-367)	17.4	646 (554-738)	16.8
Private	1,139 (998-1,280)	63.6	2,530 (2,304-2,757)	65.6
Self-pay	216 (172-259)	12.0	421 (356-485)	10.9
No charge	22 (8-35)	1.2	41 (22-60)	1.1
Other	102 (75-129)	5.7	212 (163-261)	5.5
Hospital Location/Teaching (% of total)**				
Rural	79 (68-90)	4.6	332 (305-360)	8.8
Urban, nonteaching	443 (382-506)	25.7	1,160 (1,035-1,285)	30.8
Urban, teaching	1,204 (1,058-1,350)	69.7	2,276 (1,996-2,556)	60.4

*t-test: $p<0.0001$
**Chi-square test: $p<0.0001$
***Chi-square test: $p<0.05$
CI – confidence interval

Discussion

This paper highlights the disproportionate burden of TBIs related to youth motorcycle activity in both traffic and non-traffic situations, with the greatest burden being among traffic-related injuries. The overall rate of hospitalized motorcycle-related injury in U.S. youth in 2006 was 14.5 cases per 100,000 people and the TBI rate was 4.6 (95% CI 3.7-5.5) per 100,000 people. Bowman et al. reported the rate of motorcycle traffic-related TBI for two different age groups from the HCUP Nationwide Inpatient Sample for the period 2004 to 2005. For 15- to 19-year-olds these were reported as 3.0-4.2 (95% CI) and for 10 to 14 they were reported as 0.8-1.3 (95% CI) hospitalizations per 100,000 (Bowman et al., 2008). Although the Bowman et al. incident rates are in the same range as our estimates, they are for different periods of time. Bowman et al. drew from a smaller sample and they did not include non-traffic crashes. Coben, Steiner, and Miller did not report rates, but their population estimates for traffic and non-traffic cases in the 15-to-19 age group were 2,479 (95% CI=1,9*06 to 3,054) whereas our 15-to-19 estimates (not shown) were 2,070 (95% CI=1,876-2,264), not statistically different.

Most studies of motorcycle injury focus on deaths, but doing so ignores the large impact on serious injury and long-term disability among survivors. For example, in 2006 CDC reported that there were 371 motorcyclist traffic deaths among people 12 to 20 years old (Centers for Disease Control and Prevention—WISQARS (Web-based Injury Statistics Query and Reporting System)). Contrasting that with the TBI traffic incidence estimates from our study (minus those who died in the hospital), one observes that there were 3,663 (95% CI=3,367-3,958) non-fatal hospitalizations, among which 1,190 (95% CI= 1,050-1,330) had TBIs, and among those an estimated 309 (95% CI= 273-346) suffered long-term TBI-related disabilities.

For all motorcycle injuries (TBI and non-TBI), the CDC's Web-Based Injury Statistics Query and Reporting System (WISQARS), which excludes in-hospital fatal injuries, reports a national estimate of 6,315 transferred/hospitalized traffic and non-traffic "motorcycle" cases age 12 to 20 for 2006, or a rate of 16.35 per 100,000 people. Our estimate of 14.5 per 100,000 was slightly lower than the estimate from the National Electronic Injury Surveillance System (NEISS). This may be explained by incomplete E-coding in the KID data, subtle differences in coding classifications or sampling, and sample variation (NEISS is based on reports from only 60 hospitals). But it suggests the sensitivity of the KID database for motorcycle injury is quite reasonable. Overall, the estimates from these data sources are not widely different, which validates the use of KID, an administrative database, as a good source of motorcycle morbidity in U. S. youths. The KID data have much less variability than previous hospital discharge-based reports and comprise a much richer data set compared to injury surveillance systems based on smaller samples. This allows for a better understanding of different injuries, diagnoses, procedures, and health care patterns by narrower age and other groupings.

There were several limitations to this study. We used ICDPIC to assign severity scores rather than actual AIS coding. Because we relied on secondary administrative data, no assessment of the underlying accuracy and completeness against the medical record was possible. While overall E-coding completeness in 2006 from the States supplying data to the KID has improved to over 90% (personal communication, AHRQ, April 2009), some underassessment of motorcycle injury was possible. It is important to note the lack of detail regarding the vehicle type inherent in ICD-9 external cause coding, as this code also includes motorized bicycles (mopeds), scooters, and mini-bikes that may or may not be registered. It is also possible that we underestimated TBI, as Shore, McCarthy, Serpi, and Gertner have shown some underreporting, especially of mild TBI, in hospital discharge data (Shore, McCarthy, Serpi, & Gertner, 2005). As in other hospital discharge data-based studies we could not detect cases who died before their hospitalization or were not admitted as inpatients. Another limitation is that no data on patient helmet use was available from hospital discharge data. Last, we have no data on any exposure indices for the youth in this study so exposure based risk (e.g., ownership levels, registration rates, licensing, number of trips, hours of riding, or miles traveled), an important factor in assessing personal risk, could not be considered. The lack of exposure data may lead to underestimating true risk for the younger age groups since they generally do not own or spend as much time or distance on motorcycles as their older counterparts.

Conclusions

As the number of youth motorcycle crashes increases so does the burden of the related deaths and serious injuries to the victims, families and society. Effective prevention efforts to reduce the risk of crashes and injury among youth, as in adult riders, are needed. Traumatic brain injuries, whether they occur in traffic or non-traffic settings, are of particular concern because of their long-term impacts and high mortality risks.

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