ORIGINAL ARTICLE

Pediatric hospitalizations for bicycle-related injuries

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Injury Prevention 2007;**13**:316–321. doi: 10.1136/ip.2007.016048

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Accepted 26 July 2007

Objectives: To determine the incidence of bicycle-related injury hospitalizations among children and adolescents 20 years of age and younger and to examine the associated use of healthcare resources.
Design: Nationally representative data from the 2003 Healthcare Cost and Utilization Project's Kids' Inpatient Database (KID).
Outcome measures: National estimates of hospitalization for bicycle-related injuries according to patient demographics, type of injury, total hospital charges, and length of hospital stay.
Results: In 2003, an estimated 10 700 children were hospitalized for a bicycle-related injury in the USA. Inpatient charges totaled nearly $200 million with a mean charge of $18 654 per hospitalization. The national rate was 12.7 hospitalizations per 100 000 children. Young adolescents aged 10–13 years accounted for the highest percentage of cases (36.6%) followed by children aged 6–9 years (25.1%). Most patients were male (76.7%) and resided in an urban area (94.4%). A head injury was diagnosed in one out of three hospitalized bicyclists; 30% were due to a motor vehicle collision.
Conclusions: Pediatric bicycle-related hospitalizations are a significant public health problem. The morbidity and mortality among children and the economic costs to society are large. The patient characteristics and injury types identified by this study should be used to develop targeted prevention strategies.

Children and adolescents aged 20 years and younger comprise more than half of the estimated 85 million bicycle riders in the USA.[1] Of all recreational sports, bicycle-related injuries are the leading cause of emergency department visits for children.[2] The US Consumer Product Safety Commission reported more than 500 000 bicycle-related injuries treated in emergency departments each year from 1990 to 2004, and, in 2003, 68% of these injury episodes involved children.[3] Bicycles are connected to more childhood injuries than any other consumer product, except the automobile.[4]

In addition to long-term disabilities suffered by child and adult bicyclists, bicycle-related injury events are associated with more than 700 annual deaths and cost more than US$8 billion each year.[5–7] Injuries to bicyclists are a serious problem not only in the USA, but have been established as a worldwide public health burden. This has prompted policymakers and researchers in several countries to develop and test prevention strategies. For example, protective helmets have been found to significantly reduce some of the most serious bicycle-related injuries.[8–11]

Despite the pressing need to continue to understand and minimize bicycle-related injuries, many previous studies have limitations. Some have been restricted to small, non-representative samples from select hospitals or single states.[12–14] Alternatively, national database analyses have failed to examine detailed patient characteristics, have concentrated only on head injuries, or have used broad age groups.[15–19] Also, the incidence and burden of the most severe injuries to bicyclists that have resulted in hospitalization have been insufficiently characterized. National studies of these injuries have been restricted to data collected by the National Pediatric Trauma Registry, which does not allow population-based estimates and only surveys trauma centers.[18–20] Furthermore, little research is available on total hospital charges and length of stay (LOS) associated with treatment of inpatient pediatric bicycle-related injuries on a nationwide scale.

The purpose of this retrospective study was to describe patterns of pediatric bicycle-related hospitalizations. This study aimed to: (1) estimate the national incidence of pediatric bicycle-related hospitalizations; (2) describe patient characteristics associated with these hospitalizations; (3) identify the major injury types and injury circumstances by gender and age; (4) describe hospital resource use in terms of total hospital charges and LOS, the two variables used by the government and private sector as standard measures.[21–23] This study identifies risk factors associated with the most disabling and costly bicycle-related injuries and can serve as a resource for developing and implementing prevention plans.

METHODS

Data source

Hospital discharge records for children and adolescents aged 20 years and younger from the Kids' Inpatient Database (KID) from 1 January 2003 to 31 December 2003 were used. The KID is a component of the Healthcare Cost and Utilization Project maintained by the Agency for Healthcare Research and Quality.[24] It is the only hospital administrative dataset designed specifically to assess the use of hospital services by newborns, children, and adolescents.[24] The 2003 KID collected hospital discharge information on pediatric treatments and resource utilization from 3438 hospitals in 36 states.[24] It included non-federal hospitals, short-term hospitals, academic medical centers, and specialty hospitals such as obstetric–gynecology, ear–nose–throat, orthopedic, and pediatric hospitals.[24] It excluded federal hospitals, short-term rehabilitation hospitals, long-term hospitals, psychiatric hospitals, and alcoholism/chemical dependency treatment centers.[24] Hospitals were assigned to six strata for random selection on the basis of ownership/control, bed size, teaching status, rural/urban location, US region, and hospital type (pediatric versus other).[24] All data are at the discharge level; therefore, patients hospitalized multiple times have multiple records in the KID. The 2003 KID was the most recent year with complete data at the time of this study.

Abbreviations: KID, Kids' Inpatient Database; LOS, length of stay; TBI, traumatic brain injury

Table 1 Actual sample and national estimates of pediatric bicycle-related hospitalizations according to patient characteristics, United States, 2003 (Kids' Inpatient Database, 2003)

Selected characteristics	Actual sample	National estimates	Weighted percentage* (95% CI)	Rate per 100 000 children†
Total	6511	10713	100.0	12.7
Age (years)				
0–2	88	147	1.4 (1.1 to 1.7)	1.3
3–5	383	644	6.0 (5.5 to 6.6)	5.5
6–9	1616	2691	25.1 (24.1 to 26.2)	16.2
10–13	2363	3921	36.6 (35.4 to 37.8)	23.8
14–17	1436	2332	21.8 (20.8 to 22.8)	14.5
18–20	532	841	7.9 (7.2 to 8.5)	6.9
Gender				
Male	4973	8211	76.7 (75.6 to 77.7)	19.0
Female	1239	2068	19.3 (18.4 to 20.3)	5.0
Patient location‡				
Urban	6158	10109	94.4 (93.8 to 94.9)	–
Rural	298	514	4.8 (4.3 to 5.4)	–
Median household income for patient's zip code				
<US$36 000	1540	2592	24.2 (23.2 to 25.3)	–
US$36 000–44 999	1590	2619	24.5 (23.4 to 25.5)	–
US$45 000–59 999	1721	2805	26.2 (25.1 to 27.3)	–
⩾US$60 000	1517	2458	23.0 (22.0 to 24.0)	–
Expected primary payer				
Private, HMO	3734	6129	57.2 (56.0 to 58.4)	–
Medicaid	1924	3180	29.7 (28.6 to 30.9)	–
Self-pay	511	842	7.9 (7.2 to 8.5)	–
Other¶	327	538	5.0 (4.5 to 5.6)	–

HMO, health maintenance organization.
*Weighted percentages do not equal 100% because cases in which the age (n = 93), gender (n = 299), race (n = 1915), patient location (n = 55), median income for patient's zip code (n = 143), or expected primary payer (n = 15) were not known are not reported.
†2000 US Census data used as denominator.
‡Urban and rural defined by the Urban Influence Code developed by the US Department of Agriculture.
¶Other includes Medicare, no charge, and other.

Variables

Bicycle-related hospitalizations

A series of *International classification of disease, 9th revision, clinical modification* (ICD-9-CM) external cause of injury codes (E-codes) were used to identify bicycle-related hospitalizations, a procedure consistent with previous research and the recommendations of the Centers for Disease Control and Prevention (CDC).[16 25 26] For each hospitalization, all four code fields were searched for the following: E800–E807 (railway accidents) with a fourth digit of 0.3; E810–E825 (motor vehicle accidents) with a fourth digit of 0.6; and E826–E829 (other road vehicle accidents) with a fourth digit of 0.1. The fourth digit identifies cases where the injured person was a pedal cyclist. Pedal cyclists are defined as individuals riding on bicycles, tricycles, and other road transport vehicles operated solely by pedals.[27] Bicycle-related injuries will be used synonymously with pedal cycle-related injuries in this study.

Type of injury

ICD-9-CM diagnosis codes were used to determine the type of injury. Guidelines from the CDC were used to group diagnosis codes into broader categories to allow meaningful comparison with previous studies.[28 29] Traumatic brain injury (TBI) was identified using the following diagnosis codes: 800–801.9 (skull fracture); 803.0–804.9 (other unqualified and multiple fractures of the skull); 850.0–854.1 (intracranial injury, including concussion, contusion, laceration, and hemorrhage); 959.01 (head injury, unspecified). TBIs are used as a standard measure of head injuries from bicycle-related events.[16–18 20] For each hospitalization, all 15 diagnosis code fields were reviewed. Patients with multiple different injuries were counted once for each injury type they sustained. Therefore, each patient may be counted in multiple injury categories during analyses of injury type.

Total charges

The KID is the only national, all-payer database of hospital discharges for children.[24 30 31] Total charges reflect the hospital bills for the entire hospital stay, excluding most physician fees.[24 32] Reported charges are those that were expected to be paid by the primary payer, not necessarily the final payment. Actual hospital costs are less than billed charges.

Statistical analysis

Data analyses were conducted using SAS V.9.1.2 (SAS Institute, Inc, Cary, North Carolina, USA) and SUDAAN V.9.0.1 (Research Triangle Institute, Research Triangle Park, North

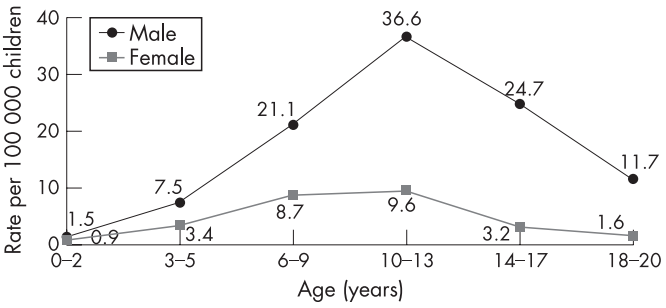

Figure 1 National rates of pediatric bicycle-related hospitalization by age and gender, 2003. Data source: Kids' Inpatient Database, 2003.

Carolina, USA) statistical software to account for the weighting structure of the KID. The SAS program was used to prepare data for analysis and to calculate descriptive statistics for total hospital charges and LOS. The SUDAAN program was used to calculate frequencies, percentages, and CIs for national estimates. Statisticians at the KID provided discharge level statistical weights to account for the complex survey design and sampling procedures. The KID was specifically designed to provide national estimates of hospitalizations using these discharge-level statistical weights.[24]

The actual sample size is a statistically unweighted number and is specified when presented in the results. All other frequencies, percentages, rates, means, medians, and sums are national estimates calculated by using the statistical weights. National estimates and weighted percentages with 95% CIs of bicycle injury-related hospitalizations were calculated by age, gender, patient location, median household income, expected primary payer, injury type, and external injury cause. Injury rates per 100 000 children were calculated by age, gender, and patient location by using the publicly available 2000 population estimates from the US Census Bureau.[33] The 2000 US Census was the latest edition with complete data.

RESULTS

Characteristics of patients hospitalized for the treatment of bicycle-related injuries

The KID collected data on 2 984 129 hospital discharges between 1 January 2003 and 31 December 2003. Of these discharges, 6511 cases involved patients hospitalized as the result of a bicycle-related injury. On the basis of these data, an estimated 10 713 (95% CI 10 701 to 10 725) bicycle-related hospitalizations occurred among children and adolescents aged 20 years or younger in the USA in 2003.

Table 1 presents national estimates and weighted percentages by patient characteristics of bicycle-related hospitalizations. In 2003, the overall rate of hospitalizations for bicycle-related injuries in children and adolescents aged 20 years or younger was 12.7 per 100 000 persons. The rate was greatest for young adolescents aged 10–13 years (23.8 per 100 000 children) and was nearly four times higher in boys than girls (19.0 per 100 000 children vs 5.0 per 100 000 children, respectively).

Patients treated in urban hospitals comprised nearly 95% of hospitalized bicyclists compared with those treated in rural areas. Private insurance, including health maintenance organizations, was the expected primary payer for more than half of all bicycle-related injuries, followed by Medicaid, which paid for about 30% of hospitalizations.

Figure 1 illustrates injury incidence by age and gender. Boys aged 10–13 years had the highest rate of bicycle-related injuries (36.6 per 100 000 children). Among girls, the highest rate of injury was in the 10–13 year age category (9.6 per 100 000 children), but the rate did not show the dramatic climb among young adolescents seen for boys. Boys had a higher rate of hospitalization than girls in all age groups.*

Type of injury and external cause of pediatric bicycle-related hospitalizations

Table 2 presents weighted percentages for injury diagnosis and external cause of hospitalizations from bicycle-related injuries. Of the estimated 10 713 hospitalized bicyclists, 52.9% (95% CI 51.9 to 53.8) were diagnosed with a fracture and 33.7% (95% CI 32.8 to 34.6) were diagnosed with a TBI. Across all age groups, fractures were the leading injury diagnoses. Most TBIs were skull fractures and concussions. A head injury was most often diagnosed in children aged 10–13 years (36.9%) followed by adolescents aged 18–20 years (36.5%). Children aged 2 years and younger had the lowest frequency of TBI (17.1%). The estimated national rate of TBI calculated from this inpatient pediatric sample was 4.3 cases per 100 000 children. This rate was highest among children aged 10–13 years (8.8 hospitalizations per 100 000 children). Superficial injury (21.3%), open wound injury (20.5%), internal injury (15.5%), and contusion (12.2%) were the next most common inpatient diagnoses for hospitalized bicyclists.

With regards to external cause of the bicycle-related injury, motor vehicles were associated with nearly a third of the hospitalizations. Motor vehicle involvement varied across age groups and was as low as 19.7% among children aged less than 2 years and as high as 39.2% among adolescents 18–20 years old. Overall, a higher percentage of injuries was caused by motor vehicles in boys than girls (30.9% vs 25.9%). The external causes of injury for most of the remaining bicycle-related hospitalizations were non-specifically coded as a pedal cycle-related event.

From the actual sample of 6511 patients, 40 (0.6%) died after being hospitalized. TBI was diagnosed in 37 (93%) of these deaths.

Hospital resource utilization for pediatric bicycle-related injuries

In 2003, the estimated total hospital charges for pediatric bicycle-related hospitalizations in the USA were US$196 088 470. Hospitalized bicycle-related injuries resulted in an average of US$18 654 in total charges for inpatient care, with a range of US$6148–19 953 when the 25% of patients with the least expensive total charges and the 25% of patients with the most expensive total charges were excluded. The most costly 2% of hospitalizations incurred more than US$100 000 per discharge in total hospital charges. The average LOS was 3.1 days, and the top 2% of injured bicyclists had a LOS of more than 2 weeks. Overall, children hospitalized because of a bicycle-related event were estimated to stay a total of 33 205 inpatient days in 2003.

Figure 2 depicts the mean and median total hospital charges and LOS for selected patient characteristics. Patients aged 18–20 years averaged the highest hospital charges (US$23 304) and the longest average LOS (3.5 days) among all age groups. Both mean hospital charges and mean LOS increased with each increase in age group. Average hospital charges and average LOS were higher for boys than girls. Finally, the mean hospital charges and mean LOS were slightly greater when Medicaid was the primary expected payer (US$19 482 and 3.3 days, respectively) than for other payers. Self-payers were charged the least (US$15 434 on average) and stayed the shortest time (2.7 days on average).

DISCUSSION

Major findings

To our knowledge, this is the first study to analyze the association of demographics and other factors with hospital resource utilization among hospitalized bicyclists using a nationally representative sample. Our actual sample of 6511 is the largest group of bicycle-related hospitalizations analyzed to date.[18–20]

In 2003, approximately 10 700 bicycle-related hospitalizations occurred among children and adolescents aged 20 years or less in the USA, resulting in nearly US$200 million in total inpatient charges. The rate of injury varied across age groups and gender, with a peak among boys aged 10–13 years. Fractures and TBI comprised the majority of injury diagnoses; one out of three patients suffered a head injury. Motor vehicles were involved in about 30% of all bicycle-related hospitalizations, and the association with motor vehicles increased in frequency with increasing age.

Table 2 Injury diagnosis and external cause of pediatric bicycle-related hospitalizations by age and gender, United States, 2003 (Kids' Inpatient Database, 2003)

	Type of injury*						
	Fracture†	TBI‡	Superficial injury	Open wound injury	Internal injury¶	Confusion	External cause motor vehicle involvement
National estimate	5664	3612	2283	2196	1656	1302	3144
Weighted percentage§	52.9 (51.9 to 53.8)	33.7 (32.8 to 34.6)	21.3 (20.5 to 22.1)	20.5 (19.7 to 21.3)	15.5 (14.8 to 16.1)	12.2 (11.5 to 12.8)	29.3 (28.3 to 30.5)
Percentage of age group**							
0–2	55.8 (47.8 to 63.8)	17.1 (11.0 to 23.2)	13.3 (7.8 to 18.8)	8.3 (3.9 to 12.8)	3.2 (0.3 to 6.0)	8.6 (4.1 to 13.2)	19.7 (13.4 to 27.9)
3–5	56.6 (52.8 to 60.5)	25.9 (22.5 to 29.3)	17.1 (14.2 to 20.0)	17.8 (14.9 to 20.8)	9.6 (7.4 to 11.9)	9.8 (7.5 to 12.1)	20.5 (16.7 to 24.8)
6–9	52.9 (51.0 to 54.7)	30.6 (28.8 to 32.3)	18.9 (17.4 to 20.4)	18.1 (16.7 to 19.6)	15.0 (13.7 to 16.4)	12.0 (10.7 to 13.2)	26.5 (24.4 to 28.8)
10–13	49.9 (48.3 to 51.5)	36.9 (35.4 to 38.4)	22.6 (21.3 to 23.9)	20.6 (19.3 to 21.8)	15.8 (14.7 to 17.0)	11.9 (10.9 to 13.0)	29.1 (27.3 to 31.0)
14–17	54.8 (52.8 to 56.8)	34.7 (32.8 to 36.7)	24.0 (22.3 to 25.7)	23.0 (21.3 to 24.7)	18.2 (16.6 to 19.7)	12.5 (11.1 to 13.8)	33.8 (31.4 to 36.3)
18–20	56.6 (53.2 to 59.9)	36.5 (33.3 to 39.8)	23.6 (20.7 to 26.4)	26.9 (23.9 to 29.9)	15.1 (12.7 to 17.5)	16.4 (13.9 to 18.9)	39.2 (35.1 to 43.4)
Percentage of gender group††							
Male	52.0 (50.9 to 53.1)	34.5 (33.5 to 35.6)	22.2 (21.3 to 23.1)	21.1 (20.2 to 22.0)	16.9 (16.1 to 17.7)	12.5 (11.8 to 13.2)	30.9 (29.7 to 32.2)
Female	53.7 (51.6 to 55.9)	33.4 (31.4 to 35.5)	21.1 (19.3 to 22.8)	21.0 (19.3 to 22.8)	11.8 (10.4 to 13.2)	12.3 (10.9 to 13.7)	25.9 (23.5 to 28.5)

*The six types of injury with the highest percentages are listed.
†Fracture includes fractures of the face, neck, trunk, and extremities but does not include skull fractures.
‡Traumatic brain injury (TBI) includes skull fractures, intracranial injury, and unspecified head injuries.
¶Internal injury includes thorax, abdomen, and pelvic injuries.
§Percentages add up to more than 100 because some children sustained more than one injury.
**Cases in which the age was not known (n = 93) are not reported, which affects percentages.
††Cases in which the gender was not known (n = 299) are not reported, which affects percentages.

The distribution of bicycle-related hospitalizations showed distinct trends across patient characteristics, especially gender and age. Our study of a large, inpatient sample supported previous research indicating that more than 70% of bicycle-related injuries occurred in males.[12 13 18–20 34] In part, male predominance among US bicycle riders explains this.[1] We identified children aged 10–13 years as having the highest rate of hospitalization for bicycle-related injuries. Data from both the National Electronic Injury Surveillance System and the National Center for Health Statistics have identified the same high-risk group for bicycle-related injuries.[3 25]

TBI accounted for 33.7% of children hospitalized for a bicycle-related injury. The frequency of head injury among pediatric bicyclists is useful for estimating the number of injuries that may be preventable through the use of a bicycle helmet. Two studies examining national emergency department data estimated that head injuries account for 9–14% of all pediatric injuries treated in emergency departments.[3 25] On the other hand, national studies focusing solely on pediatric trauma centers have found that about half of all bicycle-related hospitalizations were due to a TBI.[18–20] The higher proportion of head injury in our sample of hospitalized patients and in pediatric trauma centers may reflect the disproportionate number of TBI cases that require hospitalization and that are more severe compared with other types of bicycle-related injury.[5 20]

Almost one-third of all bicycle-related injuries involved a motor vehicle, and this percentage increased with increasing age. This agrees with previous studies, which have reported the association of 32–46% of pediatric bicycle-related hospitalizations with motor vehicle-related events.[13 19 35] In contrast, a study using national emergency department data for pediatric patients estimated the involvement of motor vehicles to be less than 5%.[25] This discrepancy implies that motor vehicles may be linked to the more severe bicycle-related injuries, which comprise a larger portion of inpatient admissions.

The approximate US$200 million in total hospital charges is the first national projection for the cost of pediatric bicycle-related hospitalizations in the USA. This is a fraction of the reported total cost of bicycle-related injuries to society, US$8 billion.[7] The average charge per hospitalized bicyclist in our research (US$18 654) was greater than the US$9577–13 864 estimated by one state's trauma center.[35] The latter study concentrated on adult bicyclists, which may suggest that pediatric bicycle hospitalizations incur higher charges.

Study limitations

Several limitations should be considered in the evaluation of the results of this study. The KID only collects data on hospital discharges. Our findings may not be representative of bicycle-related injuries treated in other healthcare settings or those that did not receive medical attention, and therefore may underestimate the overall burden of bicycle-related injuries. This study analyzed only the most severe and costly pediatric bicycle-related injuries—that is, those requiring hospitalization. Deaths of injured bicyclists are underestimated because patients who died before hospitalization are not included. In addition, our research relied on external cause of injury codes to identify hospitalizations related to bicycle events. We could not identify cases that were not coded for a bicycle-related injury. Therefore, national estimates of hospitalizations for bicycle-related injuries may be under-reported in this study. Our estimated charges for bicycle-related hospitalizations do not account for long-term indirect costs associated with serious injuries, which make up most of the overall economic burden.[16] Finally, the rates of bicycle-related injuries by age and gender reported in this study are population-based; however, they do

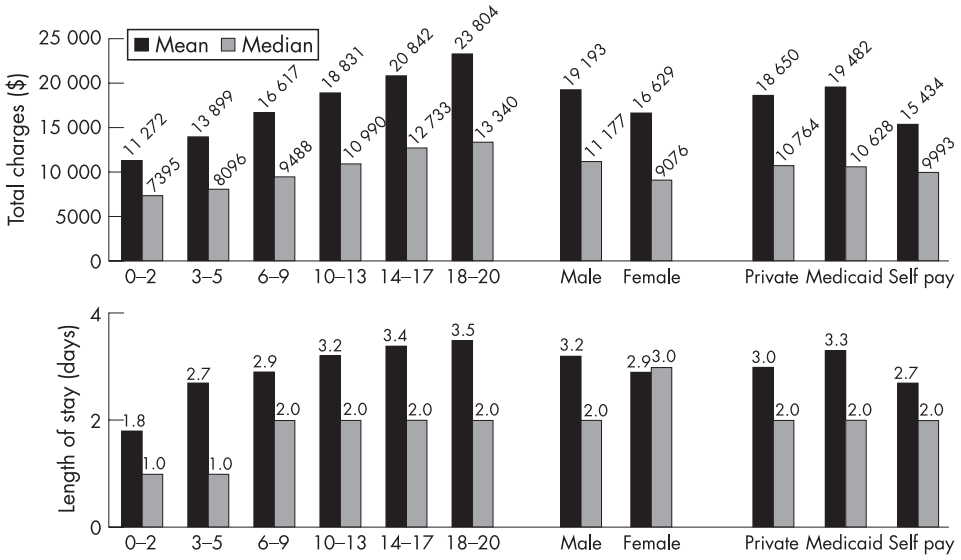

Figure 2 Mean and median total hospital charges and length of stay for bicycle-related hospitalizations by patient age, gender, and primary payer, United Stated, 2003. There were 138 cases with missing hospital charge data. Data source: Kid's Inpatient Database, 2003.

Key points

- There were 12.7 bicycle-related hospitalizations per 100 000 children under 21 years of age in 2003.
- The highest rate of bicycle-related hospitalization was in the 10–13 year age group for both boys and girls.
- A traumatic brain injury was diagnosed in one out of every three children hospitalized for a bicycle-related injury.
- Nearly 30% of all bicycle-related injury hospitalizations involved motor vehicles.
- Total inpatient charges were nearly US$200 million dollars, and the average length of hospital stay was 3 days.

not take into consideration the different proportions of each age and gender group that actually ride bicycles.

CONCLUSIONS

Implications for prevention

Despite some limitations, this study demonstrates the magnitude of bicycle-related injuries among US children and adolescents as a compelling public health problem. The high rate of hospitalization and use of healthcare resources identified in this study supports a call for increased attention to this source of pediatric injury nationally. The variations in hospitalization rates, hospital charges, length of hospital stay, and type of injury across age and gender groups are important for developing targeted prevention measures. By describing the epidemiology and hospital resource use of the most severe bicycle-related injuries that require hospitalization, the findings of this study can be used to promote practices to lessen the morbidity and mortality of pediatric bicycle-related injuries.

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Competing interests: None.

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LACUNAE

Study debunks full-moon injury beliefs

Ever whacked your thumb with a hammer, or wrenched your back after lifting a heavy box, and blamed the full moon? It's a popular notion but there's no cosmic connection, Austrian government researchers said in July. Robert Seeberger, a physicist and astronomer at Austria's Ministry of Economic Affairs, said a team of experts analyzed 500 000 industrial accidents in Austria between 2000 and 2004 and found no link to lunar activity. The study said that on average there were 415 workplace accidents registered per day. Yet on days when the moon was full, the average actually dipped to 385, although the difference was not statistically significant. The lunar influence theory dates at least to the first century AD, when the Roman scholar Pliny the Elder wrote that his observations suggested ''the moon produces drowsiness and stupor in those who sleep outside beneath her beams''.

Ted Miller, from Pacific Institute for Research & Evaluation, noted that his institute had found the same thing when we analyzed hospital admissions for suicidal acts.

USA Today; http://tinyurl.com/216672. Contributed by Les Fisher and Ted Miller.