Using Trauma Registry Data to Guide Injury Prevention Program Activities

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Background: Injury prevention programs should be based on objective injury data. This study demonstrates how local injury data can be used to help guide injury prevention programs.

Methods: We reviewed trauma registry data (2004–2006) from a Level I pediatric trauma center. Data included demographic information, anatomic location of injury, mechanism of injury, safety device utilization, Injury Severity Score (ISS), and temporal and geographic variables. The Injury Prevention Priority Score for each mechanism of injury was calculated.

Results: There were 1,874 trauma patients. Most admissions were among white males, aged 11 years to 15 years (mean, 7.9 years ± 5.2 years). Most admissions occurred during summertime and on weekend evenings. Blunt injuries (92%) and fractures (56%) predominated (mean ISS, 5.9). A severe ISS >15 was highest among 11 year to 15 year and lowest among patients older than 15 years ($p < 0.01$). Falls, cut, or pierce, ATV, and off-road motorcycle ranked highest in the Injury Prevention Priority Score. Of the 134 motor vehicle occupants, 52% (n = 70) were restrained in car seats/seat belts. Only 15% of bicyclists, 24% of motorcyclists, and 58% of ATV riders wore helmets.

Conclusion: A significant percentage of injured children and adolescents were not using proven effective injury prevention devices at the time of their injury. These data identified areas for further study and will help guide community injury prevention programs at our institution.

Key Words: Trauma epidemiology, Injury control, Pediatrics.

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Trauma is one of the leading causes of morbidity and mortality worldwide.[1] In the United States, trauma is a major public health problem and is the leading cause of death for children aged 1 year to 18 years.[2,3] In 2006, there were 8,644 unintentional injury-related deaths in this age range, which is approximately four times greater than the next leading cause of death. This clearly demonstrates the need for both specialized care and preventive measures.[4] It has been demonstrated that severe traumatic injuries should be treated at a trauma center.[5] The American College of Surgeons (ACS) verifies trauma centers and mandates that they collect and report injury data to the National Trauma Data Bank.[5]

Trauma registries capture data for 13 functions including injury surveillance, advocacy, research, education and training, hospital reports, state reports, quality improvement/quality assurance, trauma accreditation, resource allocation, auditing, federal reports, caseload verification, and reimbursement.[6] These data can be useful for improving clinical trauma care and describing the epidemiology of injuries at a local, regional, and national level.

The ACS also mandates that trauma centers should be actively involved with injury prevention efforts.[5] Injury prevention programs and policies may be influenced by many factors including population needs, financial support, media attention, and local/national events. Developing these programs based on reliable information is important, especially in times of limited financial resources. Efforts should be based on objective data, but identifying and analyzing local data sources can be challenging. The purpose of this study is to describe the frequency and patterns of injuries found in pediatric patients treated at Connecticut Children's Medical Center and to describe how this information can be used as an objective guide for injury prevention efforts.

MATERIALS AND METHODS

Data were obtained from the Connecticut Children's Medical Center trauma registry from 2006 to 2008. Enrollment criteria for the study were as follows: all patients with the International Classification Diseases, Ninth Revision, Clinical Modification discharge diagnosis 800.00 to 959.9 and were admitted or who died after receiving evaluation or treatment or were dead on arrival or who was transferred into or out of hospital for the treatment of an acute injury. Patients were excluded for any late effects of injury, blisters, contusions, abrasions, insect bites, or foreign bodies.

Data collected include age, gender, and race. Age was categorized into five groups (<1 year, 1–5 years, 6–10 years, 11–15 years, and >15 years). The anatomic location (traumatic brain injury, other head, neck, face, spine, torso, upper extremities, lower extremities, others, and unspecified) and type of injury (fracture, contusion, open wound, internal, and all others) were categorized using the Barell Injury Diagnosis Matrix.[7] The mechanism (e.g., motor vehicle occupant) and

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intent of injury (unintentional, self-inflicted, assault, legal intervention, and unknown) were categorized using the Centers for Disease Control External Cause Matrix.[8] Safety and protective devices used included helmets, protective padding, clothing, seatbelts, and airbags. Injury severity was based on the Injury Severity Score (ISS)[9] and categorized as mild, (ISS = <9), moderate (ISS = 9–15), or severe (ISS = >15). Length of stay, time of admission (month, day, and hour), and place of injury (street, home, other, and unknown) were identified. The town of residence was mapped using geographic information system software (ArcGIS version 9.2, Environmental System Research Institute, Redland, CA).[10]

Injury Prevention Priority Score (IPPS) was computed, which ranks the cause of injury by frequency and severity using the method described by Haider et al.[11] and summarized as follows:

1. Compute the mean and standard deviation (SD) of the distribution of observed frequencies and mean ISS across injury mechanisms;
2. Using the mean and SD of the observed frequencies, compute a z score to represent the relative frequency of each injury mechanism;
3. Compute the sum of the two z scores for each mechanism;
4. Compute the SD of the z score sums;
5. Compute a new set of z scores by dividing each z score sum by the SD of the z score sums; these new z scores have mean = 0 and SD = 1;
6. Compute the IPPS by computing a T score ($T = 50 + 10[z]$); the resulting T scores (IPPS) have a mean of 50 and an SD of 10, by definition.

Length of stay and discharge disposition (home, nursing facility, home health care, morgue, and rehabilitation facility) were also collected. Frequency and percents were calculated for all variables. To address the association between age and ISS, Pearson's χ^2 test was used. A two-tailed $p < 0.05$ was considered as statistically significant in bivariate analysis. All data were analyzed by using SPSS software version 12.0.1 (Environmental System Research Institute, Redland, CA).[12] This study was approved by the Connecticut Children's Medical Center Institutional Review Board.

TABLE 1. Trauma Patient Demographics (n = 1,874)

	Male		Female		Total	
	Number	Percent	Number	Percent	Number	Percent
Age group						
<1	78	6.2	56	9.1	134	7.2
1–5	356	28.3	204	33.3	560	29.9
6–10	319	25.3	180	29.4	499	26.6
11–15	441	35.0	135	22.0	576	30.7
16–19	66	5.2	38	6.2	104	5.5
Missing					1	0.1
Total	1,260	67.2	613	32.7	1,874	100.0
Race/ethnicity						
White	770	61.1	388	63.3	1,158	61.8
Black	123	9.8	50	8.2	173	9.2
Hispanic	201	16.0	101	16.5	302	16.1
Asian/Pacific island	10	0.8	5	0.8	15	0.8
Native American	1	0.1	1	0.2	2	0.1
Other	154	12.2	67	10.9	221	11.8
Unknown	1	0.1	1	0.2	2	0.1
Missing					1	0.1
Total	1,260	67.2	613	32.7	1,874	100.0

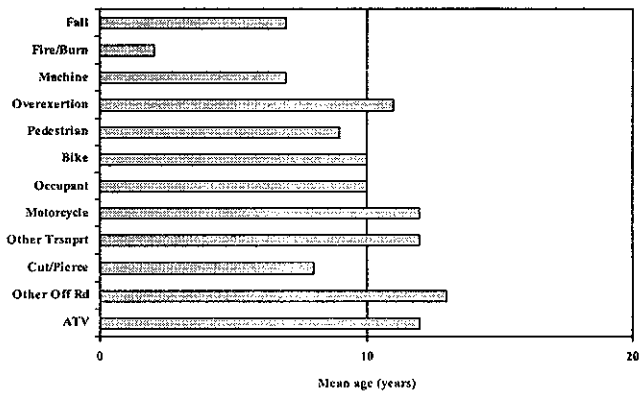

Figure 1. Cause of injury by mean age (3 yr average).

RESULTS

Demographics

There were a total of 1,874 patients in the study. Seven percent <1 year, 30% 1 year to 5 years, 27% 6 years to 10 years, 31% 11 years to 15 years, and 5% >15 years. Mean age was 7.9 years (±5.2 years), and a median age of 8.0 years. A majority of patients were male (67%) and white (62%; Table 1). In addition, injuries were classified by age (Fig. 1).

Temporal Characteristics

There were 566 cases in 2006, 608 in 2007 and 700 in 2008 and most patients were admitted from May through October. Saturday (17.1%) and Sunday (17.6%) were the busiest days of the week. The evening (6:00 PM–9:00 PM) hours had the most admissions (27.1%).

Injury Location

Most injuries occurred on the street (27%) and home (48%). Although patients resided in most Connecticut towns, most patients lived in the greater Hartford region (Fig. 2).

Injury Type

Blunt injuries (92%) were most prevalent, and 50% were fractures. The remaining injuries were classified as penetrating (5%) and burns (3%). Injuries to the upper extremity (32%) were most common; followed by lower extremity (20%); other head, face, and neck (13%); traumatic brain injury (12%); torso (10%); vertebral column and spinal cord (1%); and the remaining were either unclassified or missing from the registrar (12%; Table 2).

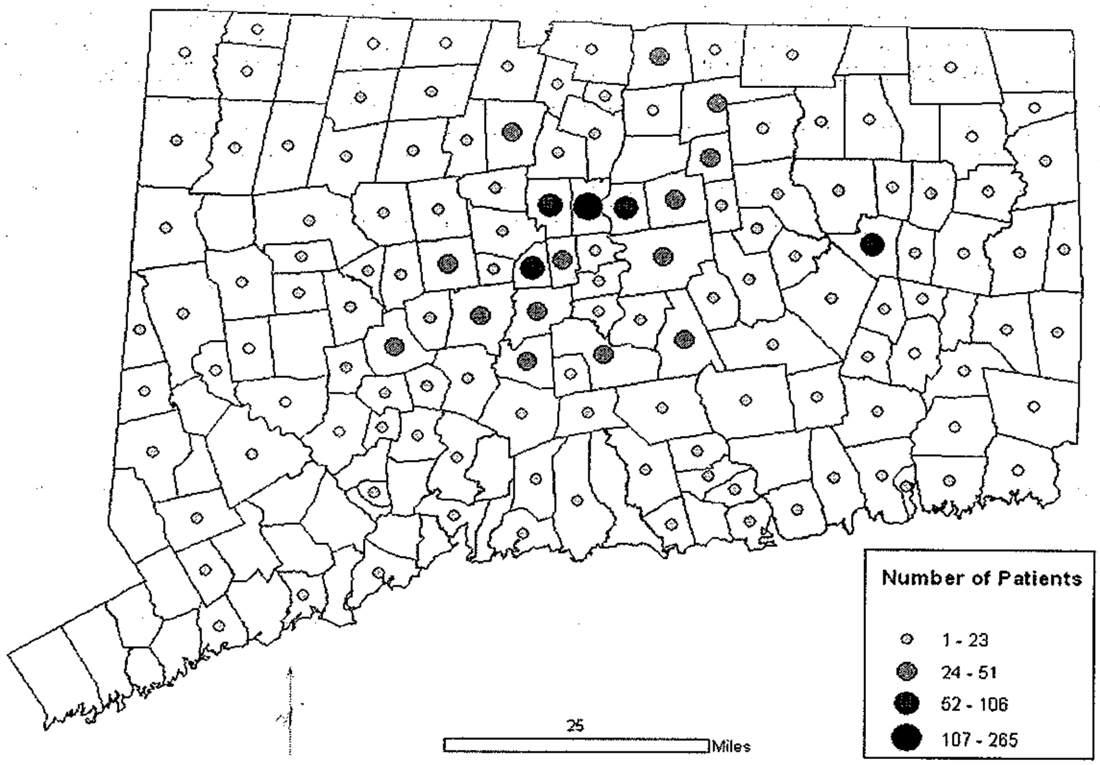

Figure 2. Pediatric trauma patients by town of occurrence (n = 1864).

Injury Severity

The mean ISS was 5.91 (±5.8). The mean Trauma and Injury Severity Score was 0.98 (±0.08). Among all patients, 73.9% had a mild ISS score of <9, 17.4% had a moderate ISS of 9 to 15, and 8.6% had a severe ISS of >15. The percentage of mild ISS <9 patients was highest among persons with age 1 year to 5 years (34.7%) and lowest among those with age >15 years (5.3%; $p < 0.01$). Patients with a severe ISS >15; it was highest among the 11 years to 15 years (47.2%) and lowest among those with age >15 years (6.2%; $p < 0.01$). In the mild <9 ISS group, the percentage was six times higher in 1 year to 5 years than those of >15 years of age patients (34.7%) versus (5.3%), $\chi^2 = 99.196$ and ($p < 0.01$).

Injury Intent and Mechanism

Most injuries were unintentional (95%), and a minority were attributed to assault (3.5%), intentional (0.5%), and other (1%). The leading mechanisms of injury were falls (43%), motor vehicle crashes (14%), struck by or against (11%), and sports (9%) and the remaining were minor categories (23%; Table 2). Further detail regarding motor vehicle injuries demonstrates that most were occupant injuries (50%) followed by pedestrian (27%), pedalcycle (15%), and motorcycle (8%). Details of the pedalcycle injuries indicate the type of injuries are predominately fractures (49%); contusions and superficial injury (24%); traumatic brain injury (12%); other head, neck, and face (12%). These patients were noted to have 21% helmet use (Table 3).

Injury Prevention Priority Score

According to the IPPS, fall was among the highest ranked mechanisms (score 52.2). A large struck by or against was the second most frequent mechanism but was ranked last (score 45.2) based on low ISS, these included a large proportion of sports-related injuries (Table 4).

DISCUSSION

This study presents a comprehensive description of patients admitted to a pediatric Level I trauma center. We identified major epidemiologic patterns of injury including who was admitted, when, the place of injury, injury type and body location, injury cause, and safety devices used. A large proportion of our patients were white males across all ages. Most admissions occurred in the summer months and mostly on the weekends and evening hours, which was similar to other trauma centers.[13,14] Some of the trauma patterns identified in our study were similar to national trends including comparable injury intent and mechanisms. However, the percent of patients with a mild, moderate, and severe ISS was different.[15] Our patient population had a lower percentage of injury severity in each ISS category when compared with national data, mild (74% vs. 40%), moderate (30% vs. 17%), and severe (10% vs. 8%). Nearly all injuries were classified as unintentional and blunt. These were predominantly fractures and occurred more frequently on the upper body. A moderate ISS was highest for the mechanism classification of falls.

TABLE 2. Injury Descriptions (n = 1,874)

	Number	Percent
Injury type		
Fracture/dislocation	1,071	57.2
Internal	266	14.2
Contusion	258	13.8
Open wound	185	9.9
Burns	56	3.0
All other	38	2.0
Body region		
Traumatic brain injury	232	12.4
Other head, neck, face	237	12.6
Spine	16	0.8
Torso	180	9.6
Upper extremity	597	31.9
Lower extremity	382	20.4
Other and unspecified	36	1.9
Missing	194	10.4
Injury intent		
Unintentional	1,786	95.3
Self-inflicted	5	0.3
Assault	66	3.5
Undetermined	13	0.7
Missing	4	0.2
Leading causes of injury		
Motor vehicle traffic	607	32.4
Occupant	134	7.2
Motorcyclist	21	1.1
Pedestrian	107	5.7
Bicycle	131	7.0
Off-road vehicle	90	4.8
Transport, other	124	6.6
Fall	812	43.3
Struck by/against object	228	12.2
Cut or pierce	27	1.4
Firearm	18	1.0
All other	182	9.7

TABLE 3. Demographics of Helmet vs. No Helmet Patients (n = 131)

	Helmet (n = 28)	No Helmet (n = 103)
<12 yr (%)	89.3	66.0
>12 yr (%)	10.7	34.0
TBI (%)	12	14.6
Male (%)	75	76.7
White (%)	75	55.3
Case fatality	0	3
Length of stay (mean)	1.5	1.9
Injury severity score (mean)	6.3	7.1

Trauma registry data such as this offers objective information for injury research and program development, often providing the best source of data about severe, nonfatal injuries.[6] Summary data on all admitted trauma patients in a given area are one of the main components for assessing the epidemiology of injury including mortality rates, emergency department records, and long-term follow-up of disabilities.[3] Understanding the epidemiology of pediatric injuries that occur in a trauma centers geographic area will help direct injury prevention resources to programs that are likely to have the highest impact.

TABLE 4. Injury Prevention Priority Score Results (n = 1,864)

Rank	Cause of Injury	No. Patients	IPPS
1	Fall	812	52.2
2	Cut or pierce	18	47.0
3	ATV	40	46.7
4	Off-road motorcycle	50	46.6
5	Fire or burn	51	46.3
6	Pedal cyclist	131	45.9
7	Occupant	134	45.8
8	Sports related injury	162	45.5
9	Struck by or against	215	45.2

There are several examples of how trauma registry data have helped guide injury center research and program development. Trauma registry data have helped focus efforts of a hospital-based injury prevention outreach program in Baltimore, MD,[16] describe pediatric all-terrain vehicle trauma in West Virginia,[17] describe the epidemiology of trauma deaths because of violence in Washington, DC,[18] and examined injury outcomes in children after automobile, motorcycle, and all-terrain vehicle accidents in Columbus, OH.[19] Trauma registry data can also provide insights into the efficacy of injury prevention programs and policy efforts. For example, several studies from trauma centers have shown decreased frequency and severity of head injuries in motorcyclists wearing helmets when compared with unhelmeted motorcyclists.[20,21] Similarly, trauma registry data have shown decreases in the number of motorcyclists admitted for head injuries after the institution of mandatory helmet laws.[22]

In addition, Haider et al.[11] describe the IPPS used to identify pedestrian injury in Baltimore, MD, and motor vehicle occupant injury in Westchester, NY, as priorities for community-based injury prevention activities. The IPPS identified a mismatch between needs and resource allocations in those locations. The IPPS balances the influence of severity (based on the ISS) and frequency and ranks them accordingly. With the exception of falls, our IPPS are tightly clustered, making it somewhat difficult to determine which injuries require more attention than others. Thus, we found the use of this relatively new tool to be only partially useful in tailoring injury prevention programs to local population needs, but it has helped reinforce our injury prevention efforts addressing infant falls from furniture and toddler falls downsteps. This information also helped us to reconfigure our sports injury prevention program with an emphasis on sports-related concussion.

This descriptive study identifies epidemiologic trends in pediatric injury for the populations served by a free-standing pediatric trauma center in Connecticut and has helped prioritize our local injury prevention activities. Implementing an injury prevention program is a requirement for trauma centers being verified by the ACS.[5] This study confirmed the relevance and helped to improve many of the current research and program activities provided by Connecticut Children's Injury Prevention Center: We are developing public awareness activities based on seasonal injury trends (i.e., spring public service announcements). This information helped to strengthen and support our research and policy efforts in the areas of Teen Driving, including an upgraded graduated licensing system in the state for teenage drivers. We have also focused on ATV safety with a multicenter prospective study, which is near completion. We have initiated new infant car seat research projects to address occupant injuries and continue to promote bicycle safety. We also identified a significant proportion of trauma patients who were not using safety devices. Within our Trauma Center, we now provide standardized safety counseling on occupant restraint and helmet use for all admitted patients. Externally, through our Safe Kids and Injury Free community programs, we intensified our efforts among urban, low-income populations (young non-white males) who are less likely to consistently use occupant restraints and helmets. Overall, the use of trauma registry data is helpful to bring local public and political attention to specific injury issues, as we develop these and other injury prevention programs and policies.

In this study, we show injury occurrence at the town level, but this type of analysis can be performed on many levels. We plan further analysis of selected injuries (pedestrian) using other data sets (e.g., motor vehicle crash file from the Connecticut Department of Transportation) to identify pedestrian injury locations including neighborhood and street levels. This will allow development and implementation of targeted pedestrian safety activities for different communities with widely variable high-risk injury trends (i.e., urban street safety vs. rural bus safety programs).

A major limitation of this study is the fact that patient data are from a single trauma center. This is common to any attempt at describing injuries and associated risk factors from patients admitted to one hospital using trauma registry data.[6] In addition, only admitted patients were included who involve a higher injury severity than the general population. However, the demographic characteristics of the cohort do match those of the North Central Connecticut population served by this Trauma Center. We also identified that cases of drowning and poisoning were not included in our trauma registry. We will search for alternative data sources (i.e., poison control center data) to include this information in future evaluations.

CONCLUSION

A significant proportion of children and adolescents treated at our pediatric trauma center were not using proven effective injury prevention devices. This research has identified areas for further study and will help guide community injury prevention programs and policies in the future.

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