ARTICLE

Pediatric Violence-Related Injuries in Boston

Results of a City-Wide Emergency Department Surveillance Program

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Context: Violence-related injuries among children are common, but age-based incidence data are not easily available.

Objectives: To describe injuries due to violence in a population-based case series of children and to estimate injury incidence.

Design: Prospective surveillance of children residing in Boston, Mass, who received pediatric emergency department treatment for violence-related injury during a 4-year period beginning April 15, 1995.

Setting: Pediatric emergency departments in Boston.

Patients: Children aged 3 through 18 years who came to a hospital emergency department between April 1995 and April 1999. Violence-related injuries were defined as those resulting from a situation of conflict involving 2 or more persons with intent to harm, as assessed by health care personnel caring for the patients. Self-inflicted injuries and injuries caused by child abuse (including any injury resulting from a conflict with a parent or guardian) were excluded. Homicides of Boston children aged 3 through 18 years who were killed during the study period were included based on police data.

Main Outcome Measure: Population-based violence-related injury rates.

Results: There were 2035 injury-related visits caused by violence, which reflects a rate of 52.7 (95% confidence interval, 50.5-54.9) per 10 000 person-years. Most injuries were relatively minor; 6.4% of visits resulted in admission. The youth violence-related injury rate in Boston declined at an average rate of 12% annually during the period studied.

Conclusion: Pediatric emergency department monitoring of violence-related injury in Boston suggests that childhood injuries due to violence declined during the late 1990s.

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YOUTH VIOLENCE is a major cause of death and disability for young people in the United States, extending well beyond the purview of the health care system.[1,2] However, our understanding of youth violence is based largely on deaths, criminal justice statistics, and public surveys.[3-6] Analyses of the incidence of violence-related injuries seen at a single site[7] or during a brief period[8] provide a snapshot of violence-related injury and cannot yield stable incidence estimates. Recently, a city-wide surveillance in Washington, DC, demonstrated a decline in violence-related morbidity and mortality in the late 1990s.[9]

We sought to establish a city-wide surveillance to measure the incidence of violence-related injury to children. Public and private agencies have initiated a variety of violence prevention efforts that include changes in the police department, philanthropic support of community organizing efforts, the introduction of violence prevention curricula into schools, and media campaigns designed to affect public attitudes toward violence. Ongoing surveillance of violence-related injury may be useful in supporting the evaluation of these efforts.

RESULTS

A total of 2035 ED visits were made by Boston residents aged 3 to 18 years for the treatment of violence-related injuries during the study period. The annual incidence of violence-related injury requiring ED care was 52.7 per 10 000 person-years (95% CI, 50.5-54.9). The ratio of deaths to admissions to ED visits—the injury pyramid[9,15]—was 1:4:59.

AGE AND SEX DISTRIBUTION

The median age of the injured children was 14 years. Age distributions for male and female patients were similar, with an increasing frequency of injury as patients grew older (**Figure** and **Table 1**). The apparent decline in incidence rate at age

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SUBJECTS AND METHODS

SUBJECTS

This report includes only pediatric patients who were residents of Boston, Mass. Data were collected on all children who came for treatment of violence-related injury to the emergency departments (EDs) of Boston Medical Center, Children's Hospital of Boston, Massachusetts General Hospital (Boston), and New England Medical Center (Boston). The first 2 hospitals, which together accounted for more than 85% of all pediatric ED visits in Boston, began the surveillance program on April 15, 1995. The third hospital joined November 1, 1996, and the fourth joined February 1, 1997. The period studied was from April 15, 1995 to April 14, 1999. Two other nonhospital sites offer 24-hour urgent care services and may have diverted some local patients from the EDs; however, these sites were not included in this surveillance. The Massachusetts Department of Public Health estimated that 95% of all pediatric ED visits were accounted for by these 4 hospitals (Victoria Ozanoff, PhD, oral communication, April 1997).

METHODS

The detailed methods and rationale of this surveillance program have been previously published[6] and are summarized below.

Definitions and Inclusion and Exclusion Criteria

Violence-related injuries were defined as those resulting from a situation of conflict involving 2 or more persons with intent to harm, as assessed by health care personnel caring for patients in the EDs.[7,10,11]

Only injuries that seemed to be caused by interpersonal violence, excluding child abuse, were included in this study. Exclusion criteria included: (1) unclear intent; (2) injuries resulting from child abuse (identified by *International Classification of Diseases, Ninth Revision, Clinical Modification* code E967[12]); (3) the "other person involved" in the incident leading to injury was identified as a parent; or (4) injuries resulting from attempted suicide.

Completeness of Data

Patients were identified prospectively (at the time of visit) or retrospectively (by daily ED record review).[6] All hospitals, as a matter of policy, accept patients older than 18 years. The 2 hospitals that contributed the greatest number of patients to the study routinely accept patients up to the age of 21 years. Three of the hospitals have adult and pediatric facilities in adjoining areas and all but the most severely injured patients younger than the cut-off age receive care in the pediatric ED. Older adolescents with severe, life-threatening injuries at these institutions may have been cared for in specially equipped adult trauma rooms and may not have been included in this study. In addition, children and adolescents who died at the scene were not included in the surveillance.

Data Collection

We collected data concerning patient age, sex, and residence, injury circumstance, victim-offender relationship, drug use by the patient, medical description of injury and procedures, and weapon use. Information concerning the body part(s) injured was systematically collected beginning in 1997. Reports of homicides of persons younger than 19 years were provided by the Boston Police Department.

Rate Calculations

To determine the annual incidence of violence-related injury, we analyzed data on injuries to Boston residents. Population-based injury occurrence rates were calculated for Boston residents only, using the results of the 1990 and 2000 US Census as the denominator.[13,14] Age-specific population changes throughout the decade were approximated using a linear model, ie, assuming equal annual increases and decreases throughout the decade. We held the exposure (number of person-years) constant within each calendar year.

Numerator data were computed using all visits made by Boston residents. For the period in which only 2 hospitals participated, the actual incidence of violence-related injury was inflated by a factor of 1.16 to account for the proportion of visits seen at the other 2 centers. For the period in which 3 hospitals participated, the measured incidence of injury was inflated by a factor of 1.099 to account for the fourth hospital. These ratios were determined empirically, based on data from the period in which all 4 hospitals participated. The number of events that occurred during a specified period was assumed to follow a Poisson distribution.

Poisson regression models were used to assess the trend of incidence rate change during the 4-year period. The confidence intervals (CIs) of incidence rate ratios were constructed using a robust procedure. Regression analyses were based on 128 age, sex, and year groups (ie, 16 age, 2 sex, and 4 year groups). Data analysis was performed using Stata 7.0 (Stata Corporation, College Station, Tex).

This study was approved by the human studies committees or institutional review boards at each hospital.

18 is partially accounted for by the influx of college students to Boston. There were many fewer 17-year-old (5887) than 18-year-old residents (9625) in 1990. The number of violence-related injury visits by 17- and 18-year-olds was 294 and 222, respectively.

INJURY CIRCUMSTANCE

One or more circumstances of injury were recorded for 79.8% of all patient visits. Commonly reported circumstances of injury included: an argument (38.9%), assault (20.0%), "horsing around" (5.8%), and crimes other than assault (3.6%). The relationships between the patient and the other individual(s) involved in the incident leading to injury were: friends or schoolmates (38.2%), sibling or other family member (10%), strangers (9.0%), and boyfriend or girlfriend (3.4%).

The relationship of the patient to the other person(s) involved was unknown (or the patient was unwilling to say or the relationship was not documented) in 28.5% of all cases. The fraction of unreported relationships did not seem to be random: unknown or undocumented relationships

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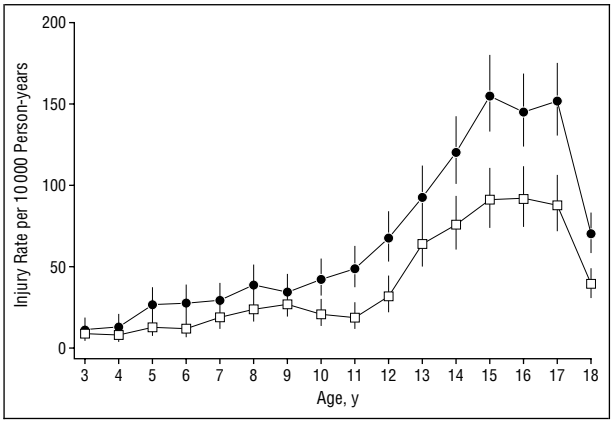

Average incidence rate of pediatric injuries, 1995-1999, per 10 000 person-years.

Table 1. Violence-Related Injury Incidence Rates by Age Group and Sex*

Age, y	Sex	IR (95% CI)	IRR (M/F)	IRR (vs Age 3-4 y)
3-4	Female	8.6 (5.4-13.1)		
	Male	12.2 (8.4-17.2)		
	Total	10.5 (7.9-13.6)	1.41	NA
5-9	Female	19.3 (16.0-23.0)		
	Male	31.7 (27.6-36.3)		
	Total	25.7 (23.0-28.6)	1.64†	2.60†
10-14	Female	41.7 (36.8-47.2)		
	Male	73.4 (66.8-80.5)		
	Total	57.7 (53.6-62.2)	1.76†	6.01†
15-18	Female	71.2 (64.3-78.5)		
	Male	122.4 (113.4-131.9)		
	Total	96.8 (91.1-102.8)	1.72†	10.1†

*Rates are reported per 10 000 person-years. IR indicates incidence rate; CI, confidence interval; and IRR, incidence rate ratio.
†$P<.01$.

were more commonly reported in adolescent than in younger patients (33.4% of those 13 years or older vs 17.8% of those 12 years and younger $P<.001$). Compared with girls, boys were less likely to have any relationship recorded (33.6% missing for male patients vs 20.0% for females; $P<.001$). Boys were also more likely to report a stranger (10.0% vs 7.3%; $P=.02$) and less likely to report a friend or schoolmate (36.3% vs 41.6%; $P<.01$) or sibling or other family member (7.4% vs 14.4%; $P<.01$).

INJURY DESCRIPTIONS

Most injuries were relatively minor, involved the head, neck, and upper extremities, and were the results of unarmed fights (**Table 2**). Most patients were treated and released, 130 (6.4%) were admitted, and 2 died in the ED (.01%).

Overall, weapon use (stab/cut, firearm, or blunt object) was reported in 25.5% of all injuries. No children younger than 10 years were treated for intentional injuries caused by firearms. Among 15- to 18-year-olds, the injury incidence rate for firearm use was 3.3 injuries per 10 000 person-years. Within this age group, males experienced an 11-fold higher incidence of injury caused by firearms compared with females (rate, 6.1 for males vs 0.5 for females).

Table 2. Description of Injury*

	No. (%)
Pathologic mechanism	
Contusion	734 (36.1)
Laceration	528 (25.9)
Head trauma	284 (14.0)
Fracture	218 (10.7)
Abrasion	144 (7.1)
Anatomic location†	
Neck	370 (31.9)
Upper extremity	362 (31.2)
Head	304 (26.2)
Trunk	161 (13.9)
Lower extremity	119 (10.2)
Eye	93 (8.0)
Genitals	46 (4.0)
Dental	36 (3.1)
External cause of injury	
Unarmed fight/assault	1174 (57.7)
Blunt instrument	338 (16.6)
Stab/cut	189 (9.3)
Human bite	85 (4.2)
Firearm	50 (2.5)
Other	282 (26.1)

*Description of violence-related injury to Boston, Mass, residents aged 3 to 18 years. Most common categories are described. Percentage may add up to more than 100% because patients may have had more than one mechanism or location. N = 2035.
†n = 1161. Anatomic location was recorded beginning in 1997.

INJURY RATES OVER TIME

The incidence of violence-related injuries in Boston was lower in each successive year of the 4-year study period (**Table 3**). Poisson regression models were used to assess the trend of incidence rate change during the 4-year period. After adjustment for the effects of sex and age, the incidence rate ratio over years was estimated as 0.88 (robust 95% CI, 0.80-0.96; $P=.005$), or a 12% rate of decline annually.

FATALITIES

Two deaths were reported to the ED surveillance system. During the study period, the Boston police reported 34 homicides (excluding 5 cases of lethal child abuse) with victims younger than 19 years. Nineteen victims were aged 18 years, 9 were 17, 3 were 16, and the remaining 3 deaths occurred in children younger than 16 years.

COMMENT

An ongoing surveillance of violence-related injuries to children aged 3 to 18 years treated in EDs in Boston has been established. During the 4-year period beginning April 15, 1995, the overall injury incidence rate was 52.7 injuries per 10 000 person-years. Older children and boys experienced higher injury rates than younger children and girls. Most injuries observed resulted from arguments between people who knew each other and were minor. During the 4-year period of the study, the rate of violence-related injury affecting youth declined by approximately 12% annually.

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Table 3. Incidence Rates by Year*

Year	IR (95% CI)	IRR (vs First Year)
4/95-3/96	65.1 (60.2-70.2)	. . .
4/96-3/97	59.3 (54.7-64.2)	0.91
4/97-3/98	46.8 (42.7-51.1)	0.72†
4/98-3/99	40.0 (36.3-44.0)	0.62†

*Incidence rates of violence-related injury per 10 000 person-years for Boston, Mass, residents aged 3 to 18 years at the time of injury. IR indicates incidence rate; CI, confidence interval; and IRR, incidence rate ratio.
†$P<.01$.

These results are subject to the inherent limitations of a health care–based surveillance system. Only those injured children who received medical care from a pediatric ED for violence-related injuries, who disclosed the circumstances surrounding the injuries, and who were properly coded would have been included in this report. Each step in the process from injury to entry in the database could have led to undercounting. In addition, the study specifically excluded injuries caused by child abuse, ie, any injuries inflicted by a parent, thus resulting in an underestimate of the overall effects of violence on children.

Injury rates reported here for older adolescents, in particular, are likely to be lower than the actual rates experienced. Some older adolescents with severe injuries were treated at adult EDs and thus were not included in this report. In addition, our finding that histories of the relationship between the patient and the other person(s) involved were more likely to be incomplete for adolescents suggests that older pediatric patients may be reluctant to divulge detailed information, which may contribute to undercounting of violence-related injuries due to a failure to accurately ascertain intent.

The decline in hospital treatment for violence-related injury parallels the decline in violent crime, youth homicides in particular.[1] The association of dropping crime rates and falling rates in pediatric violence-related injury suggests that the decrease in violence in Boston was widespread, including types of violence that are not usually included in criminal justice statistics.

Cheng et al[9] recently reported their experience with injury surveillance of children aged 10 to 19 years in Washington, DC, from June 15, 1996, to June 15, 1998. They reported significantly higher rates of violence-related injury in Washington compared with our data from Boston: 70 events per 10 000 person-years for youths aged 10 to 14 years in Washington compared with the 57.7 events reported here; for those aged 15 to 19 years, they reported 523 events per 10 000 person-years compared with our reported rate of 189. They also found that violence-related adolescent morbidity and mortality declined in Washington, similar to the trend reported here.

Previous studies have shown that a history of previous injury seems to increase a young person's likelihood of both fighting and weapon carrying, and may lead to serious mental health consequences.[16-20] While most injuries treated were relatively minor and unlikely to lead to long-lasting physical disability, these minor injuries to younger children may offer a method to identify children at risk of more serious injury as they grow older.

What This Study Adds

Violence-related injury is an important cause of morbidity and mortality in American children. Previous incidence estimates have relied on criminal justice information, surveys, and estimates derived from the experiences of single hospitals. These data suggest that youth violence is decreasing. This article reports the initial results of an emergency department–based surveillance program for the city of Boston. City-wide surveillance of pediatric violence-related injury reveals that the decline in criminal violence and homicide extends to the much more common minor injuries typically seen in pediatric emergency departments. Further study is requisite to determine if interventions focused on children with minor injuries will result in decreases in the risk of later, more serious injury.

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