

Hospitalizations Due to Firearm Injuries in Children and Adolescents

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KEY WORD

firearm injuries

ABBREVIATIONS

CI—confidence interval

KID—Kids' Inpatient Database

LOS—length of stay

TBI—traumatic brain injury

Dr Leventhal conceptualized and designed the study, interpreted the data, drafted the initial manuscript, and revised the manuscript; Ms Gaither conceptualized and designed the study, analyzed and interpreted the data, helped draft the initial manuscript, and revised the manuscript; Dr Sege helped design the study, interpreted the data, helped draft the initial manuscript, and revised the manuscript; and all authors approved the final manuscript as submitted.

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WHAT'S KNOWN ON THIS SUBJECT: Firearm injuries are the second leading cause of death among American children. Previous estimates of nonfatal injuries have relied on small samples of emergency department visits and do not allow a detailed understanding of these injuries among children and adolescents.



WHAT THIS STUDY ADDS: In 2009, there were 7391 hospitalizations for firearm-related injuries in US children and adolescents; 89% of hospitalizations occurred in males. Hospitalization rates were highest for 15- to 19-year-olds and for black males. Deaths in the hospital occurred in 6.1% of children and adolescents.

abstract

FREE

BACKGROUND AND OBJECTIVE: Despite recent national attention on deaths from firearms, little information exists about children and adolescents who are hospitalized for firearm injuries. The objective was to determine the national frequency of firearm-related hospitalizations in the United States in children, compare rates by cause and demographics, and describe hospitalized cases.

METHODS: We used the 2009 Kids' Inpatient Database to identify hospitalizations from firearm-related injuries in young people <20 years of age; International Classification of Diseases, Ninth Revision, Clinical Modification, and external-cause-of injury codes were used to categorize the injuries and the causes as follows: assault, suicide attempt, unintentional, or undetermined. Incidences were calculated by using the weighted number of cases and the intercensal population. Risk ratios compared incidences.

RESULTS: In 2009, 7391 (95% confidence interval [CI]: 6523–8259) hospitalizations were due to firearm-related injuries. The hospitalization rate was 8.87 (95% CI: 7.83–9.92) per 100 000 persons <20 years of age. Hospitalizations due to assaults were most frequent ($n = 4559$) and suicide attempts were least frequent ($n = 270$). Of all hospitalizations, 89.2% occurred in males; the hospitalization rate for males was 15.22 per 100 000 (95% CI: 13.41–17.03) and for females was 1.93 (95% CI: 1.66–2.20). The rate for black males was 44.77 (95% CI: 36.69–52.85), a rate more than 10 times that for white males. Rates were highest for those aged 15 to 19 years (27.94; 95% CI: 24.42–31.46). Deaths in the hospital occurred in 453 (6.1%); of those hospitalized after suicide attempts, 35.1% died.

CONCLUSIONS: On average, 20 US children and adolescents were hospitalized each day in 2009 due to firearm injuries. Public health efforts are needed to reduce this common source of childhood injury. *Pediatrics* 2014;133:219–225

Firearm injuries cause both serious morbidity and death in children and adolescents. Whereas vital statistics data have been used to assess the mortality rates from firearms,¹⁻⁴ only minimal national data concerning non-fatal injuries, mostly from emergency department sampling,^{1,5} have been readily available. According to the 2012 American Academy of Pediatrics policy statement on firearm injuries,² among the pediatric population firearm injuries are 1 of the top 3 causes of death among American children and the cause of 1 in 4 deaths in adolescents ages 15 to 19 years. The most recent available national data indicate that for children and adolescents <21 years of age, firearm injuries led to 3459 deaths in 2010 and nearly 21 000 emergency department visits in 2011.¹

There is, however, little information about the burden of hospitalizations in the United States due to firearm injuries in children and adolescents. One previous study examined hospitalizations due to firearm-related injuries in the United States in 1997, but did not focus on children.⁶ Hospitalizations typically occur for severe injuries and are costly; knowing the magnitude of hospitalizations attributed to firearm injuries among youth would further characterize the burden of this public health problem. Therefore, the purposes of this study were to examine the frequency of hospitalizations due to firearm injuries in children and adolescents, compare rates of hospitalizations by cause of the injury and demographic characteristics, and describe hospitalized cases.

METHODS

Study Design and Data Source

This study was a secondary data analysis of hospitalizations. We used the 2009 Kids' Inpatient Database (KID), a nationally representative sample of discharge data from acute care hospitals of children and adolescents <21 years of

age in the United States.⁷ Since 1997, the KID has been released every 3 years; the 2009 database is the most recent. Each year of the KID includes a systematic sample of 10% of uncomplicated births and 80% of complicated births and other acute care hospitalizations in the United States. The sampling frame in 2009 included 4121 hospitals in 44 states, and thus represented 96% of the US population. Weighting, which is used to calculate a national estimate, is based on the following 6 characteristics of the hospitals: rural versus urban location, region of the country, bed size, ownership/control, type of children's hospital, and teaching status.

Case Definition

Eligible hospitalizations (both nonfatal and fatal) included children or adolescents <20 years of age at the time of admission and were identified by using external-cause-of-injury E codes, which are codes that are used by hospital coders to classify the cause of an injury. We included all hospitalizations with any of the 4 E codes specifying that the injury was due to a firearm.⁸ As noted in Table 1, these codes included the following causes: unintentional injuries, suicide attempts, assaults, and undetermined as to whether the injury was accidentally or purposefully inflicted. Firearm injuries due to BB or air guns were included, whereas those due to paintballs were excluded.

Variables

Demographic information, including age at the time of the hospitalization (grouped as 0-4, 5-9, 10-14, and 15-19 years of age), gender, race, and health insurance (private, Medicaid, self-pay, or other), was obtained. Injuries were classified according to the International Classification of Diseases, Ninth Revision, Clinical Modification, codes for injuries (800-904, 910-959)⁸ and grouped into the following categories: traumatic brain injury (TBI); fracture; internal injury of the thorax, abdomen, or pelvis; open wound of head, neck, trunk, or limbs; injury to blood vessels; injury to nerves or spinal cord; and other. We excluded cases in which the only injury code was for a late effect (905-909).

We also examined whether the patient had a major procedure code or died during the hospitalization, length of stay (LOS), and costs of the hospitalization. The KID defines a "major procedure code" as any operation for diagnostic or therapeutic purposes that occurred in the operating room.⁷ Hospital costs were calculated by using hospital-specific cost-to-charge ratios, which were available for 92% of the hospitals; a weighted group average was used when the hospital-specific cost-to-charge ratios were unavailable. To account for cases with missing cost estimates, per the Healthcare Cost and Utilization Project recommendations, we adjusted the discharge weights for those cases

TABLE 1 E Codes for Causes of Firearm Injuries

Cause of Injury	E Code and Description
Unintentional	E922.0-E922.4, E922.8-E922.9 (accidental caused by firearms and air gun missiles)
Suicide attempt	E955.0-E955.4, E955.6, E955.9 (suicide and self-inflicted injury by firearms)
Assault	E965.0-E965.4 (assault by firearms)
Undetermined	E985.0-E985.4, E985.6 (injury by firearms or air guns undetermined whether accidentally or purposefully inflicted)

E code, external-cause-of-injury code.

remaining after excluding observations with missing values for costs.⁹

Analysis

We calculated the weighted number of hospitalizations due to firearm injuries and the weighted numbers by cause, age, gender, race, and insurance. To calculate the incidence of hospitalizations due to firearm injuries for 2009, the numerator was the weighted number of hospitalizations and the denominator was the number of children or adolescents based on 2009 intercensal data.¹⁰ We also calculated the incidence of hospitalizations by cause, age, gender, race, and insurance. Confidence intervals (CIs) were calculated by using the Taylor series in SAS version 9.3 (SAS Institute, Cary, NC). To compare rates between groups, we calculated relative risks.

We examined the percentage of cases with specific kinds of injuries and the percentage of children and adolescents who died in the hospital. To examine LOS and costs, we calculated means, 95% CIs, and ranges.

This study was considered exempt from approval by the Yale Medical School's institutional review board.

RESULTS

As shown in Table 2, there were an estimated 7391 (95% CI: 6523–8259) hospitalizations of children and adolescents due to firearm injuries in 2009. Hospitalizations due to injuries from assaults were the most frequent ($n = 4559$), whereas hospitalizations

due to suicide attempts were infrequent ($n = 270$). In younger children, hospitalizations due to unintentional injuries were the most common. For example, in children <10 years of age, 75.4% of the 378 hospitalizations were due to unintentional injuries. Of all hospitalizations, 89.2% were in males, and this marked difference in gender was found regardless of the cause of the injury. There were significant racial differences according to the cause of the hospitalization (Table 3). Overall, 47.2% of the hospitalizations occurred in black children and adolescents, and blacks comprised 53.8% of assaults, 35.8% of unintentional injuries, 53.8% of injuries that were of undetermined cause, and 13.6% of suicide attempts ($P < .0001$).

Of the hospitalizations, 49.6% were covered by Medicaid, 25.3% by private health insurance, 16.6% by self-pay (uninsured), and 8.5% by other types of health insurance. This distribution of payments was similar for assaults, unintentional, and undetermined. In contrast, private health insurance paid for nearly half (49.3%) of those hospitalized for suicide attempts, whereas Medicaid covered only 24.8%.

Hospitalizations due to firearm injuries occurred at an overall rate of 8.87 (95% CI: 7.83–9.92) per 100 000 persons <20 years of age. Figure 1 shows the rates for each cause and age group; for each cause, the relative risk is shown for each age group compared with the referent group of 0- to 4-year-olds. For each cause, the rates were substantially higher in older children compared with those <15 years of age. When the rates

in the oldest age group were compared with those in the youngest age group, 15- to 19-year-olds were 121.2 (95% CI: 85.2–172.4) times more likely to be hospitalized for an assault and 145.6 (95% CI: 29.2–726.7) times more likely to be hospitalized for a suicide attempt; in contrast, the relative risk of being hospitalized for an unintentional injury was 10.0 (95% CI: 8.4–11.9).

Significant racial and gender differences in hospitalization rates for firearm injuries were observed. Black children and adolescents had the highest rate of hospitalizations for firearm injuries at 25.13 (20.65–29.61) per 100 000 compared with other races: 7.93 (6.36–9.50), 6.56 (5.18–7.95), and 2.58 (2.24–2.92) for Hispanic, other, and whites, respectively. The rate among males was 7.9 (7.3–8.5) times higher than for females: 15.22 (13.41–17.03) compared with 1.93 (1.66–2.20) per 100 000. When males were examined separately and rates stratified by race and age group (Fig 2), rates were highest in blacks, overall and in each age group. The overall rate for black males was 44.77 (36.69–52.85), which was 10.5 (9.8–11.2) times higher than the rate for white males (4.28; 3.71–4.86), and the rate for black adolescents aged 15 to 19 years was markedly elevated at 148.71 (121.06–176.37), which was 13.1 (12.1–14.2) times higher than the rate for whites in the same age group (11.33; 9.69–12.96). Similar age and racial differences were noted for females (Fig 3), but the differences were not as dramatic as for males. For example, the overall rate for black females was 4.82 (4.33–5.32), which was 6.2 (5.2–7.4) times higher than for white females (0.78; 5.15–7.42).

The most common injuries due to firearms were open wounds (52.0%), fractures (50.4%), and internal injuries of the thorax, abdomen, or pelvis (34.2%). Two types of injuries with potential for long-term neurologic problems occurred less

TABLE 2 Causes of Firearm Injuries by Age

Age	Assault	Suicide	Unintentional	Undetermined	Total
0–4 years	31 (18.0)	2 (0.9)	133 (76.8)	8 (4.4)	173 (2.4)
5–9 years	47 (23.0)	2 (0.8)	152 (74.2)	4 (2.1)	205 (2.8)
10–14 years	267 (38.2)	21 (3.0)	377 (53.9)	34 (4.9)	699 (9.5)
15–19 years	4143 (66.8)	239 (3.9)	1459 (23.5)	360 (5.8)	6201 (84.0)
Unknown	70 (62.6)	8 (6.8)	28 (25.0)	6 (5.6)	112 (1.5)
Total ^a	4559 (61.7)	270 (3.7)	2149 (29.1)	413 (5.6)	7391

Data are presented as n (row %).

^a Individual cells may not add to totals due to rounding.

TABLE 3 Causes of Firearm Injuries by Race/Ethnicity

Race/Ethnicity	Assault	Suicide	Unintentional	Undetermined	Total
White	393 (8.6)	133 (49.4)	630 (29.3)	51 (12.3)	1207 (16.3)
Black	2455 (53.8)	37 (13.6)	770 (35.8)	222 (53.8)	3485 (47.2)
Hispanic	947 (20.8)	39 (14.3)	333 (15.5)	72 (17.4)	1391 (18.8)
Other	214 (4.7)	11 (4.2)	86 (4.0)	18 (4.3)	329 (4.5)
Unknown	549 (12.0)	50 (18.6)	329 (15.3)	51 (12.2)	978 (13.2)
Total ^a	4559 (61.7)	270 (3.7)	2149 (29.1)	413 (5.6)	7391

Data are presented as *n* (row %).

^a Individual cells may not add to totals due to rounding.

frequently; TBI (9.2%) or injuries to the nerves or spinal cord (6.4%) occurred in 1123 young people. Younger children, however, were more likely to have a TBI: 20.8% in children <5 years of age (*n* = 173) compared with 8.3% in those aged 15 to 19 years (*n* = 6201) (*P* < .0001); among those <5 years of age, ~1 in 4 suffered either a TBI or damage to the nerves or spinal cord. Age differences were less notable for the other types of injuries suffered.

Of the children and adolescents hospitalized for firearm injuries, 61.5% had a major procedure (conducted in an operating room), and 453 (6.1%) died during the hospitalization. The percentage of children who died in the hospital was highest for patients with firearm injuries due to suicide attempts

(35.1%) compared with assaults (5.0%) or unintentional injuries (4.1%). The overall mean LOS was 6.14 (95% CI: 5.77–6.52; range: 0–233) days. LOS was longest for assaults (6.41 days; 95% CI: 5.92–6.91 days) and shortest for cases of unintentional cause (5.62 days; 95% CI: 5.15–6.10 days) (*P* = .02). The average cost per hospitalization was \$19 755 (95% CI: \$18 401–\$21 109; range: \$320–\$605 693). Overall, the estimated direct hospital costs of firearm-related hospitalizations were \$146 710 029.

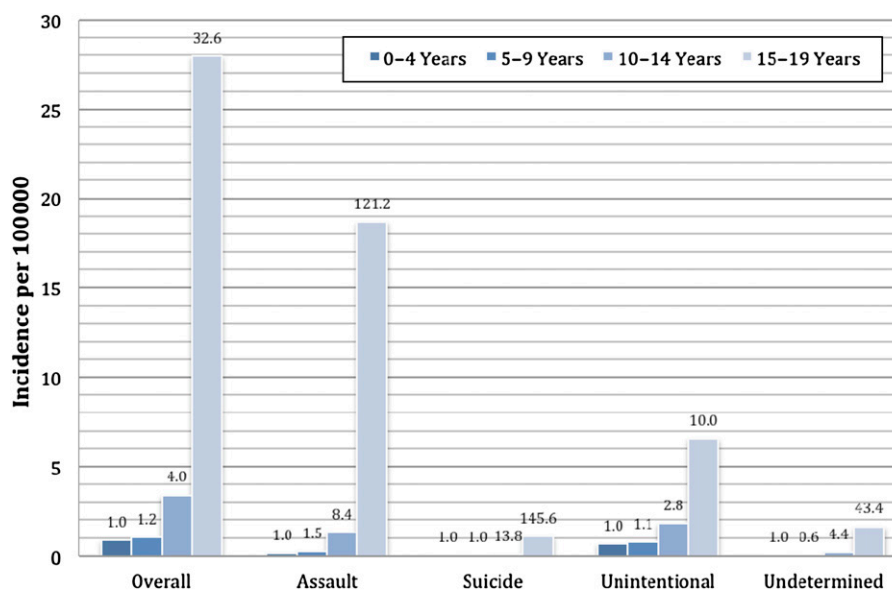
DISCUSSION

Although national attention has recently focused on deaths in the United States due to firearms,^{2–4} our study is the first to call attention to the thousands of children and adolescents who

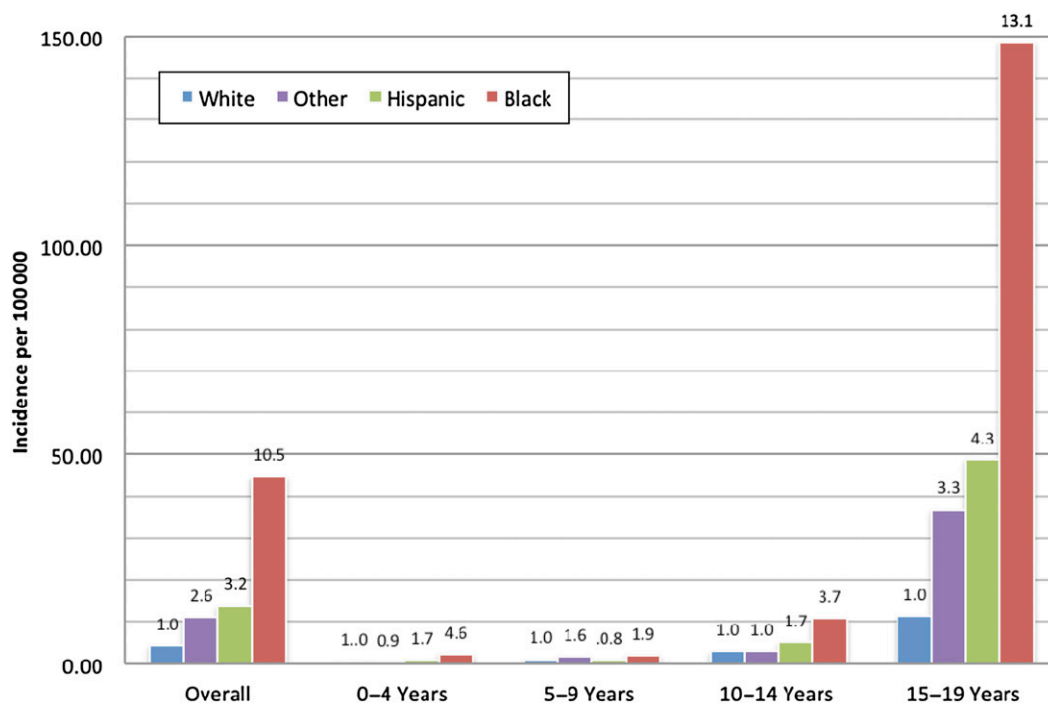
survive their immediate firearm-related injuries and go on to suffer substantial morbidity and hospitalizations. In 2009 alone, an estimated 7391 hospitalizations occurred in children and adolescents in the United States because of firearm injuries, and 453 of these young people (6.1%) died in the hospital. The incidence of firearm injuries resulting in hospitalizations was 8.87 per 100 000 for those <20 years of age. The rate was highest for 15- to 19-year-olds at 27.94. Almost 1100 children under age 15 (3 per day) were hospitalized for firearm injuries.

Firearm injuries are an important and preventable cause of morbidity in the pediatric age range. The major cause of injury in young children was an unintentional injury, whereas in adolescents, most hospitalizations resulted from assault. Hospitalizations due to suicide attempts were uncommon and had a high (35%) in-hospital death rate, in keeping with the very high case-fatality rate of suicide attempts made with a firearm.¹¹

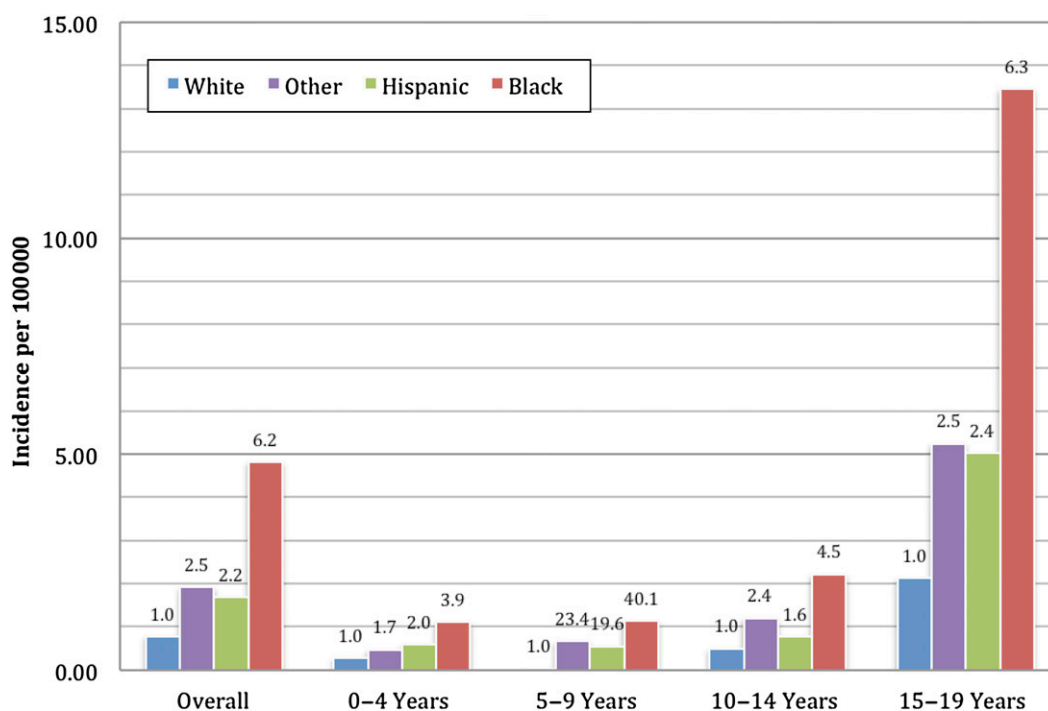
Firearm injuries resulting in hospitalization have a large economic impact. The estimated direct hospital costs for

**FIGURE 1**

Hospitalization rates for firearm-related injuries by cause. The number above each bar indicates the relative risk of hospitalization (referent = 0- to 4-year-olds).

**FIGURE 2**

Hospitalization rates for firearm-related injuries among males by race and age. The number above each bar indicates the relative risk of hospitalization (referent = white race).

**FIGURE 3**

Hospitalization rates for firearm-related injuries among females by race and age. The number above each bar indicates the relative risk of hospitalization (referent = white race).

all hospitalizations were \$147 000 000 in 2009. This figure does not include costs for physician services incident to the hospitalization, emergency medical services, rehabilitation or home health care, hospital readmissions due to late effects of the injuries, mental health treatment or social services, or any indirect economic costs.

Our results reinforce several findings from published work. First, firearm injuries contribute to health disparities, individually and in communities; among all US children and adolescents, males, blacks, and those receiving Medicaid were at the highest risk of firearm-related hospitalizations. As noted previously,⁶ the vast majority (89%) of all hospitalizations due to firearm injuries were in males, who experienced a firearm-related hospitalization rate of 15.22 per 100 000 compared with the rate in females of 1.93. This gender difference was apparent even in young children. Furthermore, 70% of hospitalizations among black males could be attributed to assault. Whereas previous studies and reports have noted the increased risk of black adolescents 15 to 19 years of age being injured or dying from firearm injuries,² our results indicate that the yearly risk of hospitalization for this group is 1 per 672. These high rates of violence have wide-ranging effects on affected communities.¹²

Second, studies have attempted to estimate the economic costs of firearm injuries to children and adolescents. For example, in a recent report based on data from 2006 to 2008 from 47 emergency medical services in the West, firearm injuries incurred the highest acute care costs of any childhood injury: \$28 510 per patient, nearly double the costs of the next highest injury category (being struck by a motor vehicle: \$15 566).¹³

Due to the young age of the patients in our study, most of the societal costs are likely to result from disability. A 2004 study, using data from the National

Pediatric Trauma Registry, reported that nearly half of the children hospitalized for firearm injuries were discharged with a disability.⁵ In our study, although most injuries were open wounds or fractures, 1123 patients suffered TBIs or spinal cord injuries, and TBIs were more common in the youngest children. Further research is needed to identify the overall short- and long-term economic consequences of nonfatal firearm injuries to children.

The major strength of this study is the sampling frame of the KID, which includes a large sample of US hospitalizations of children and adolescents <20 years of age. The only other national estimates of hospitalizations due to firearm injuries are available from the National Epidemiologic Injury Surveillance System—All Injury Program, which samples 66 hospital emergency departments; the National Epidemiologic Injury Surveillance System estimates that 6496 (95% CI: 3302–9690) children and adolescents were hospitalized for firearm injuries in 2009.¹

Our study has at least 3 limitations. First, the KID counts hospitalizations and not children or adolescents. To calculate population rates, we made the assumption that a patient was hospitalized once during the year for the firearm-related injury. In addition, to minimize the likelihood of counting hospitalizations that were related to the sequelae of an acute injury, we excluded cases in which the only injury code was for a late effect. Second, 6 states were not included in the sampling frame of the KID; these states, however, represented only 4% of the US population in 2009. Third, the KID provides no information on the long-term health of children and adolescents; thus, we are unable to provide data on the lasting effects from brain, spinal cord, or other types of injuries nor are we able to provide data concerning the long-term impact of firearm-related injuries on psychological well-being.

A better understanding of the range of injuries caused by firearms may be useful in the design and monitoring of public health efforts for firearm injury prevention. Most unintentional firearm injuries in children,¹⁴ like many childhood poisonings, fires, and drownings, occur in the home. Public health efforts have led to improvements in the burden of childhood injury associated with other household hazards. A combination of consumer product regulations, public health education, and zoning restrictions has been implemented and aimed at reducing these household injuries, resulting in steady declines in deaths due to residential fires¹⁵ and childhood drownings.¹⁶ In contrast, there have been no robust public health efforts to reduce firearm injuries, based, in part, on federal restrictions on firearms research.^{17,18}

Our findings underscore the important role that pediatricians and other health care providers who care for children can play in the primary prevention of firearm injuries in children and adolescents. At least 1 previous randomized trial has revealed the efficacy of physician counseling concerning safe storage of firearms,¹⁹ and the American Academy of Pediatrics recommends that pediatricians discuss firearm safety during early childhood, when other common household hazards are discussed, and again in the context of adolescent development.²⁰

CONCLUSIONS

This study highlights the substantial morbidity and mortality in children and adolescents due to firearm injuries. In 2009, in the United States, almost 7400 persons <20 years of age were hospitalized for firearm injuries. The rates of hospitalizations were highest in 15- to 19-year-olds and in black males. Public health efforts should be dedicated to reducing this common source of childhood injuries.²¹

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