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# Pediatric Firearm Injuries: Do Database Analyses Tell the Whole Story?

**Michelle Veenstra[1] · Heather Schaewe[1] · Lydia Donoghue[1] · Scott Langenburg[1]**

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**Abstract** Firearm injuries cause significant morbidity and mortality in the pediatric population and a large economic burden to our health care system. Recent events have increased awareness in the public and in turn for those in the medical field. Many local and national studies have evaluated various aspects of firearm-related injuries across the United States in an effort to identify an intervention that may assist with prevention or management of firearm-related injuries or death in this vulnerable population. In the 1990s, there was a significant decrease in pediatric firearm-related injuries and mortality. The reason for this decline remains unknown with many theories including improved laws, increased awareness, and increased prevention efforts. However, this trend did not continue into the 21st century, and firearms remain one of the leading causes of death in the pediatric population.

**Keywords** Pediatrics · Firearm injuries · Mortality · Trauma · Gunshot wounds

## Introduction

Among high-income countries, the United States has the highest rate of firearm-related deaths across all age groups with over 30,000 Americans dying from firearms and another 75,000 injured [1••]. Firearm-related injuries are the leading cause of trauma-related deaths in the pediatric population in the United States and trauma is the leading cause of death for children [1••, 2••]. Individual studies have shown no change in the number of firearm injuries or mortalities after the decrease seen in the mid-1990s [3, 4]. A query of the Web-based Injury Statistics Query and Reporting System (WISQARS) national database for 2013 reports 2465 deaths in children ages 0–19 due to firearms with 5.11 deaths/100,000 males and 0.79 deaths/100,000 females [5].

Many studies on both local and national levels have been conducted to evaluate pediatric firearm-related injuries and fatalities; however, the data vary significantly. Studies performed from local trauma registries with chart reviews are limited and only focus on one area of the nation, while many national database studies only include limited data points. For this reason, many databases are lacking details surrounding the incidents of firearm injury or mortality that may be beneficial in creating prevention programs. In addition, many national databases are limited to only evaluating patients presenting to a specific department of hospitals or specific hospitals that participate in data collection for the database. Many studies using databases for evaluation include children of different ages and include older teenagers, some including patients aged 18–20 years. This age range is not considered representative of pediatric traumas. Many people argue that these studies should be analyzed by age range, focusing on the younger versus older age groups, or analyze each age group separately due to different circumstances involved in the shootings. This article reviews the studies that have evaluated pediatric firearm-related deaths and injuries across the United States. This article does not contain any studies with human or animal subjects performed by any of the authors.

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✉ Michelle Veenstra
mveenstr@dmc.org

[1] Department of Pediatric Surgery, Children's Hospital of Michigan, 3901 Beaubien Blvd, Detroit, MI 48201, USA

## Firearm Storage in the United States

There are currently over 300,000,000 firearms in circulation in the United States, and firearm-related mortality is higher in children from states with increased firearm availability [2••]. A study in 2006 reviewed firearm storage practices in homes with children and found that 21.7 % of households stored a firearm loaded and 31.4 % stored a firearm unlocked. The percentage of households with unlocked guns was higher in the group with children over the age of 13 compared to those with younger children (42 vs. 29 %) [6]. In addition, the ownership of a firearm made a person 4–5 times more likely to be shot in an assault or commit suicide [1••, 6]. Multiple studies have shown a benefit to storage of firearms locked and unloaded as well as educating parents and distributing gunlocks [1••, 2••, 7•, 8]. Laws requiring safe storage of firearms have resulted in a decrease of firearm-related suicides, but laws to restrict the sale of firearms have not had the same effect, possibly due to the high rate of illegally obtained firearms [1••]. A study in Flint, MI found 23 % of 14–24-year-old assault patients reported carrying a firearm and of these, only 17 % were obtained legally [9].

## National Studies of Firearm-Related Injury and Mortality Over Decades

A national study from 1993 to 2000 of the National Electronic Injury Surveillance System and National Vital Statistics System for patients 14 years of age or younger found 22,661 patients or 4.9 per 100,000 individuals presented to an Emergency Department and in addition 5542 children or 1.2 per 100,000 individuals died from a firearm-related injury. During the study period, they found that both the injury and the mortality rate decreased >50 % [10]. This study highlights the decrease in mortality seen in the 1990s. Unfortunately, there have been no studies showing a significantly continued decline in injury or mortality rates since the late 1990s. The decline has been attributed to the improved economic status of the American population, increased prevention efforts for firearm safety in the pediatric population, and increased laws limiting access to firearms by children; however, there are no studies proving any one of these to fully account for the decrease noted during this time.

From 2001–2010, the incidence of firearm-related injuries was 24 % higher than previously reported when reviewing the National Hospital Ambulatory Medical Care Survey [11]. This study did not include injuries caused by nonpowder firearms, which also occur at a high frequency, but less frequently cause mortality. It did, however, include all Emergency Department visits as well as outpatient ambulatory center visits and found 198,969 firearm-related visits (0.06 % of all visits) in those 10 years. Of those, only 2 % of the patients died and the fatality rate was 0.4 per 100,000 children per year [11]. Other studies have reported mortality rates of up to 20 % but have included varying age groups, some up to 19 years old [3, 10–12]. Only one study included medical examiner's records and found a 29 % mortality rate after shootings in children in Tennessee, significantly higher than studies that do not include these records [13].

## Urban Versus Rural Effect

From 1999–2006, the risk of firearm-related mortality was found to be similar across rural and urban communities throughout the United States [14]. This study also demonstrated that demographics and the situation surrounding the trauma were very different between rural and urban communities. Mortality in rural areas was most often due to suicides or unintentional injury, while mortality in urban areas was due to homicides. Most mortality due to violence or suicide was in patients older than 16 years of age, while unintentional injuries most often occurred in patients under the age of 14 years [14]. National database studies combine these very different communities for analysis which can make them less applicable to specific communities around the country. These data highlight the importance of designing prevention programs that are specific to each community. This is also apparently when comparing studies performed from local databases and chart reviews throughout the country. Recent studies, all from urban communities, include reviews from Atlanta, Miami, and Detroit (currently in publishing) (3,4). Many similarities between these studies exist including the prevalence of male African-American victims but also contain variables that are different between communities including the percentage of violence-related injuries, the time of year that firearm injuries are most common, and mortality rates.

## Relevance of Age

A review of the National Trauma Data Bank from 2007 and 2008 in patients under the age of 18 years found that three of every five pediatric mortalities due to firearms were in teens. In addition, the number of deaths per year in children less than 9 years of age has not changed since the 1990s. There were 577 pediatric mortalities in the 2 years of this study. In addition, the years of potential life lost in African Americans were 17,446, Hispanics 6776, and Caucasians 6718. This study identified 30,940 years of potential life

lost from patients ($N = 577$) over a 2-year period due to pediatric firearm mortalities [15].

## The Burden of Cost

The Nationwide Emergency Department Sample (NEDS), the largest all-payer hospital based emergency department dataset, was used to evaluate Emergency Department visits in 2008 due to firearm-related injuries in children less than 18 years of age [16]. There were a total of 14,831 visits to Emergency Departments for treatment of a firearm-related injury. Of these patients, 36 % were admitted to the hospital, 3.6 % died in the Emergency Department, and 6 % of admitted patients died prior to discharge. Total charges associated with the Emergency Department visits and admissions were 371 million dollars and 33,404 days were spent in the hospital [16]. A total of 817 children died during 2008 in this database, compared to the 577 identified using the NTDB for 2007–2008 [15].

The 2009 Kids' Inpatient Database (KID) was used to identify firearm-related injuries among hospitalized children under the age of 20 years. This study excluded paintball gun injuries, but included other nonpowder firearms such as air guns and BB guns. They identified 7391 hospitalizations due to firearm-related injuries and 453 deaths (6 % of patient sample) that occurred after hospital admission. The highest percentage of deaths occurred in those who attempted suicide (35 %) [17]. The mean length of stay was 6 days and the average cost per hospitalization was $19,755. They also found that traumatic brain injury and spinal cord injuries, the most likely injuries to lead to prolonged disability, were most common in the younger patients. These were seen in approximately one in four patients less than 5 years old compared to 8.3 % of patients aged 15–19 years old [17]. The main criticism of this study was the inclusion of older adolescents and young adults up to the age of 20 years since the largest group of patients with injury or mortality was those aged 15–19 years old.

## Epidemiology

The situation surrounding the shooting of pediatric patients varies by age group. Teenagers and older children are injured or killed by firearms in situations of violence or suicide [17]. After peaking in 1994, the firearm associated death rate fell for patients 15–19 year olds, related to a drop in homicide deaths due to firearms. However, the highest mortality rate across all firearm injuries is seen in patients 15 or older [1••]. In 2009, 84.5 % of homicides in patients 15–19 years old were due to firearms [1••].

## Storage and Unintentional Deaths and Suicides

In 2009, suicide was the third leading cause of death in 15–19 year olds, following accidents and homicide, and firearms were the most common cause of suicide accounting for 736 deaths [1••]. The highest rate of mortality in firearm injuries is suicide and is linked to access to firearms at home [1••, 13, 18]. Suicide deaths were more likely Caucasians and females were more likely injured or killed by suicide than any other intent [7•]. Laws requiring safe storage of firearms and the storage of firearms locked and unloaded have significantly decreased suicides in adolescents due to firearms [1••, 18].

Patients in younger age groups are more likely to be shot by a firearm unintentionally and at home [12, 17]. These injuries are also likely to occur from friends or family members [1••]. A review of unintentional firearm deaths in the United States from 1991 to 2000 found the six states where people were more likely to store firearms loaded had twice as many people die [19]. Households that stored guns locked and unloaded, with ammunition locked in a separate location had lower rates of unintentional injuries and suicide from firearms [8]. Prevention efforts for this age group can be focused on safety and best storage practices at home. Targeting education and safe storage practices for parents would be beneficial for this group of children. *Child access protection laws* have been adopted in many states and decrease suicide and unintentional firearm injury rates in children 12 years of age and younger [7•, 11]. A study comparing firearm injury rates between states with strict firearm laws to those without strict firearm laws found a significant decrease in the number of injuries in states with strict firearm laws, particularly in children 12 years of age or younger [20•].

## Race

African-Americans are more likely affected by firearm-related mortality and males are more commonly affected than females [7•, 11–14, 17]. African-American males over age 15 have a yearly risk of hospitalization of 1 in 672 due to a firearm injury [17]. Other risk factors identified include age over 12 years old and those with a criminal history [11]. Caucasians are more likely to be involved in the younger age groups and in unintentional situations or suicides, while African-American children are more likely to be killed by firearms in violent situations [12]. The number of potential life years lost for African-American children was almost three times that of Hispanics and Caucasians in firearm mortalities from 2007 and 2008 [15].

**Table 1** National database studies evaluating firearm-related injuries and deaths in the pediatric population over the past 20 years

| Year | Database | No. of injuries | No. of deaths | Patient ages | Reference |
|---|---|---|---|---|---|
| 1993–2000 | National electronic injury surveillance system & national vital statistics system | 22,661 | 5542 | 0–14 | 10 |
| 1999–2006 | National center for health statistics national vital statistics system | | 23,649 | 0–19 | 14 |
| 2001–2010 | National hospital ambulatory medical care survey | 198,969 | 3979 | 0–19 | 11 |
| 2007–2008 | National trauma data bank | | 577 | 0–17 | 15 |
| 2008 | Nationwide emergency department sample | 14,831 | 817 | 0–17 | 16 |
| 2009 | Kids' inpatient database | 7391 | 453 | 0–19 | 17 |
| 2009 | National inpatient sample | 286 | | 0–18 | 20 |
| 2013 | Web-based inquiry statistics query and reporting system | | 2465 | 0–19 | 5 |

These studies are important for identifying demographics that may be targeted for prevention of firearm-related injuries. They are, however, incomplete, as many hospitals do not contribute data to these databases. Table 1 highlights the variability of reported data by each database that is used for data collection. The mortality rates in these studies are likely underrepresented because those patients that are declared dead on the scene or dead on arrival are not included in the database analyses. The Center for Disease Control identifies violence-related deaths and provides accurate data for demographics related to different age groups and is obtained from the National Electronic Injury Surveillance System and National Vital Statistics System. These data can be limited by not including details surrounding the incident such as the place the injury occurred, the person who shot the gun, and the type of firearm involved. The National Violent Death Reporting System (NVDRS) was created to track violent deaths, including firearm-related mortality. This system tracks additional information from law enforcement, medical examiner reports, and state data [21]. The NVDRS is currently only funded in 17 states but has the potential to provide accurate, specific information when funded across the country.

## Conclusion

Firearm-related mortality is a large contributor to pediatric deaths in the United States. Many studies have been completed in the past 20 years to evaluate these deaths, yet there have been no great advances in decreasing the death rate related to firearm injuries in this population since the late 1990s. According to the Center for Disease Control, since 1999 there has been a slow decrease in the number of deaths and crude mortality rate due to firearms in the pediatric population with the most recent data from 2013 showing a crude mortality rate of 3.0/100,000 [5]. Various professional organizations including the American Academy of Pediatrics, American Pediatric Surgery Association, and Society for Adolescent Medicine have published position papers with recommendations and support of further research, prevention programs, and laws to address this problem in the pediatric population [1••, 2••, 22]. In order to create the best prevention programs, we need accurate national and local data to tailor prevention programs to each community and the nation.

### Compliance with Ethics Guidelines

**Conflict of Interest** Michelle Veenstra, Heather Schaewe, Lydia Donoghue, and Scott Langenburg declare that they have no conflicts of interest.

**Human and Animal Rights and Informed Consent** This article does not contain any studies with human or animal subjects performed by any of the authors.

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