

# Rural Versus Urban Pediatric Firearm Injuries: A 10-year Review at a Level 1 Trauma Center

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**Abstract:** While hospitalization rates in rural versus urban pediatric firearm injuries nationwide has been previously investigated, studies highlighting the differences across the spectrum of pediatric care are limited. The purpose of this study is to describe the epidemiology of pediatric firearm injuries in a North Texas level 1 trauma center in rural versus urban settings and supplement knowledge for injury prevention. Retrospective review of the trauma registry was done to identify children 0-18 years of age admitted to the Emergency department, inpatient service, or clinics between 2009-2019 for firearm injuries. Data points were cross-referenced through chart reviews. A descriptive analysis was conducted on data collected and stratified by location of injury; rural vs urban. Demographic data, type of firearm used (air propelled or powder propelled), shooter relationship, and injury severity scores were also collected. A chi-square analysis was conducted to determine associations and logistic regression analysis to determine the odds ratio of associations. A total of 247 patients met study criteria. Males accounted for 73% of all victims, of which 58% were in urban areas. Stratified by race, 36% of patients were Hispanic, followed by 30% White ( $p < 0.001$ ). Patients were slightly younger in rural areas  $8.2 \pm 3.74$  compared to their urban counterparts  $9.2 \pm 4.34$  ( $p = 0.129$ ). Air propelled firearms were used most often in both rural (52.2%) and urban (54.2%) areas ( $p = 0.808$ ). Black children were 3.6 times (CI: 1.8-7.5) more likely to sustain injuries from powder propelled firearms as compared to their White counterparts ( $p < 0.001$ ). Most shooters in both rural and urban areas were family members (57.5% and 39.7% respectively;  $p = 0.112$ ). Most injuries were unintentional; 95.6% of rural and 74.5% of urban injuries ( $p < 0.002$ ). Most injuries were classified as minor according to the injury severity score: rural 42.2% and urban 71.1%. However, injuries occurring in rural areas had a higher percentage in the moderate (28.9%), serious (11.1%) and severe (17.8%) categories respectively ( $p < 0.001$ ). In conclusion, firearm injuries occurred mostly in urban areas. The mean age of the patients was younger than 10 years. Additionally, injuries were often unintentional, caused by family members. More seriously injured children were in rural areas. This highlights the importance of firearm education to families with children.

**Keywords:** Ballistic, Emergency Department, Firearm, Injury, Injury Severity Score

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## 1. Introduction

Between the 2009 and 2019, approximately 32,086 children ages 0 to 19 years died from gunshot wounds [1]. In addition, 17,062 children are injured by firearms on average each year [2]. Across all ages, in 2014, firearm injuries were indicated in the same number of deaths as motor vehicle collisions [3]. This is largely a preventable consequence of gun ownership in the United

States and presents a large burden on the medical community through a high use of medical resources and lasting disability. DiScala and Sege (2004) found that 40% of hospitalized children injured by firearms were admitted to the Intensive Care Unit and multiple studies have shown that approximately half of pediatric patients discharged home after being hospitalized for a firearm related injury were discharged with some level of disability [4, 5]. Decreasing the number of preventable firearm injuries and deaths in children has become paramount to the medical community. In

2017, the Firearm Safety Among Children and Teens (FACTS) Consortium, a National Institute for Child Health and Human Development funded group, was formed who identified 5 major areas needed in pediatric firearm research. These areas are epidemiology and risk and protective factors, secondary prevention and sequelae, cross-cutting prevention factors, policy, and data enhancement [6].

Gun ownership is common with rates of gun ownership at 29.1% nationally in 2013, and state rates ranging from 5% to 60% [7]. This variability across the country with respect to firearm accessibility and gun culture seems to add increased difficulty in the prevention of firearm injuries in children. There appears to be a relationship between storage practices, specifically increased rates of guns that are stored unlocked and loaded, and increased rates of unintentional firearm deaths in both adults and children [8, 9]. Furthermore, the degree of urbanization changes the causation of these injuries in children with more unintentional injuries and suicides seen at higher frequencies in rural environments [10]. Age, gender, and race also seem to play a role in the reason behind why children become injured [10-12]. In Alabama, African American children were most often injured because of violent shootings (60%), whereas white children were shot unintentionally 80% of the time [11].

There is a gap in firearm research over the last 20 years with few studies providing regional data, and even fewer studies providing comprehensive data. These studies have shown the majority of pediatric firearm injuries occur in adolescents [10, 13, 14], are generally from handguns [10, 13], and mortality is not affected based on rural versus urban areas [15]. Grossman et al (1999) determined that most guns involved in self-inflicted and unintentional firearm injuries originate either from the victim's home or the home of a friend or relative [16]. In a large multi-center study by Herrin et al (2018), urban versus rural hospitalizations from firearm injuries were compared. Assaults occurred at the highest rate in urban 15- to 19-year-olds and unintentional injuries were the leading cause of hospitalizations in all groups but occurred at a higher rate in rural 5- to 9-year-olds and 10-to-14-year-olds as compared to their urban counterparts [17]. However, there are currently no studies comparing urban versus rural pediatric firearm injuries in all settings of pediatric care as compared to inpatient alone. Comprehensive data across the entire country is difficult because of the previous lack of funding in firearm safety research and the variability in gun ownership, gun culture, gun laws, and gun injury patterns. There is benefit for local pediatricians, family physicians, and lawmakers to know the patterns of firearm injuries in their region in order to give education and advice tailored to their community's needs. By studying the differences in all rural and urban shootings in all encounter settings, even at a regional level, specific interventions can be targeted to further decrease preventable firearm injuries that can educate this region and may translate to other regions as well.

The purpose of this study is to describe the epidemiology of firearm injuries in a pediatric tertiary care level 1 trauma center, in a high gun-owning state. This study specifically seeks to describe the context of firearm injuries between urban and rural

communities in children who survive transport to the hospital.

Children's Health, Children's Medical Center in Dallas, Texas is the only level 1 pediatric trauma center in the region and sees over 120,000 visits annually to the Emergency Department (ED) with an average of 25 visits or more a year related to firearm injuries. As a tertiary referral center, this population represents both rural and urban populations in the surrounding region, and serves as a unique way to study what differences may exist between the two populations.

## 2. Methods

After institutional research board approval, a retrospective review of charts in the trauma registry was conducted for children aged 0-to 18-year-olds who were treated in this institution's ED, hospital, or clinics from January 1, 2009 to June 21, 2019 for firearm related injuries.

In the institution where this study was conducted, all trauma patients transferred from an outside facility, are evaluated in the ED prior to disposition. This includes those who have been evaluated at transferring hospitals and subsequently transferred to the study site hospital. The trauma registry captures all trauma patients seen in the ED or seen in the clinics. Although the study institution sees a majority of trauma patients under the age of 15, a few older patients are transferred from other facilities, are inadvertently brought from the scene, or walk in on their own accord. For this reason, patients 0 to 18 years were included.

Data collected included: demographics, injury date, admission date, length of stay, means of arrival to the hospital, discharge status, geographical data (zip code where the injury occurred), firearm type, and intent, shooter relationship, and injury severity score.

Type of firearm was differentiated into air propelled and powder propelled firearms. Air propelled firearms were defined as air soft guns and pellet guns. Powder propelled firearms were included handguns, rifles and shot guns. Injury intent was classified as intentional, unintentional, and unknown. Intentional injuries included those that occurred where the intent of the firearm discharge was to do harm. Examples of intentional injuries are suicides and assaults. Unintentional injuries were designated based on the idea that no harm was intended with the discharge of the firearm. These include instances when children were playing with the weapon, when the weapon was being cleaned, when it was being used for hunting, or when the weapon was being transported.

Geographical data was stratified by zip code to designate a rural versus urban area based on the 2010 Rural-Urban Commuting Area (RUCA) Codes. RUCA codes are a classification system used by the US Department of Agriculture as a measurement of rurality based on population density, daily commuting, and urbanization [18]. There are many ways that RUCA codes can be aggregated. Categorization A designates 4 classifications: urban focused, large rural city/town focused, small rural town focused and isolated small town focused [19]. For the purposes of this study, large rural, small rural, and isolated small town were combined into the single heading of "rural."

All analysis was conducted using SPSS Statistical Package version 26.0 (SPSS Inc, Chicago, Ill, USA). Descriptive statistics (frequencies, percentages, means and standard deviations) were conducted to describe patient demographics and other independent variables of interest. Bivariate analysis (Chi-square) was conducted to determine if comparative variables such as shooter relationship, intentionality, ballistic type, ISS scores, differ by rural vs urban setting. Logistic regression analysis was conducted to obtain the odds ratio and confidence interval of experiencing other outcomes of interest such as intentional shooting and injuries from powder propelled firearm.

P-values less than 0.05 were considered statistically significant.

### 3. Results

There were 313 patients identified in the trauma database for firearm injuries during the time period for this study. Sixty-six patients were excluded for not having an injury zip

code identifiable. This left 247 patients for data analysis.

#### 3.1. Demographics

The mean age of all children injured by firearms were less than 10 years old; however, the mean age of children injured in rural areas did not differ significantly from those injured in urban areas ( $p=0.129$ ) (Table 1).

Males accounted for approximately three-quarters of the study population (73%,  $n=181$ ). However, there was not a significant difference in male versus female predominance in urban versus rural injuries  $p=0.224$  (Table 1).

This population consisted of mainly Hispanic patients 36% ( $n=90$ ) of firearm injury victims overall, followed by Caucasian patients at 30% ( $n=74$ ), and then Black patients at 26% ( $n = 66$ ). In urban areas, Hispanics were the largest population (39.3%) followed closely by Blacks (30.3%). In rural areas, 54.4% were predominantly White children followed by Hispanic children (23.9%) (Table 1).

Table 1. Demographics.

Variables	Rural (n=46) n (%)	Urban (n=201) n (%)	X <sup>2</sup> p-value	T-test p-value
Age in years (Mean $\pm$ SD)	8.2 $\pm$ 3.74	9.2 $\pm$ 4.34		0.129
Gender			0.224	
Female	9 (19.6)	57 (28.4)		
Male	37 (80.4)	144 (71.6)		
Race			<0.001*	
White	25 (54.3)	49 (24.4)		
Black	5 (10.9)	61 (30.3)		
Hispanic	11 (23.9)	79 (39.3)		
Other	5 (10.9)	12 (30.3)		

#### 3.2. Geographic Region and Intentionality

Most firearm injuries occurred in an urban area (81%;  $n=201$ ). For reference, in the 2010 census, 84.7% of Texans live in an urban area [20]. 25.5% of urban injuries ( $n=50$ ) were intentional while only 4.4% of rural injuries were intentional ( $n = 4$ ) ( $p<0.002$ ). This was statistically significant (Figure 1).

#### 3.3. Type of Firearm

The ballistics were identified in 96% ( $n=238$ ) of injuries. Air propelled firearms were used in the majority of both urban (54.2%,  $n=104$ ) and rural (52.2%,  $n=24$ ). There was no statistically significant difference ( $p=0.808$ ) based on

geographical location i.e rural vs urban (Figure 2).

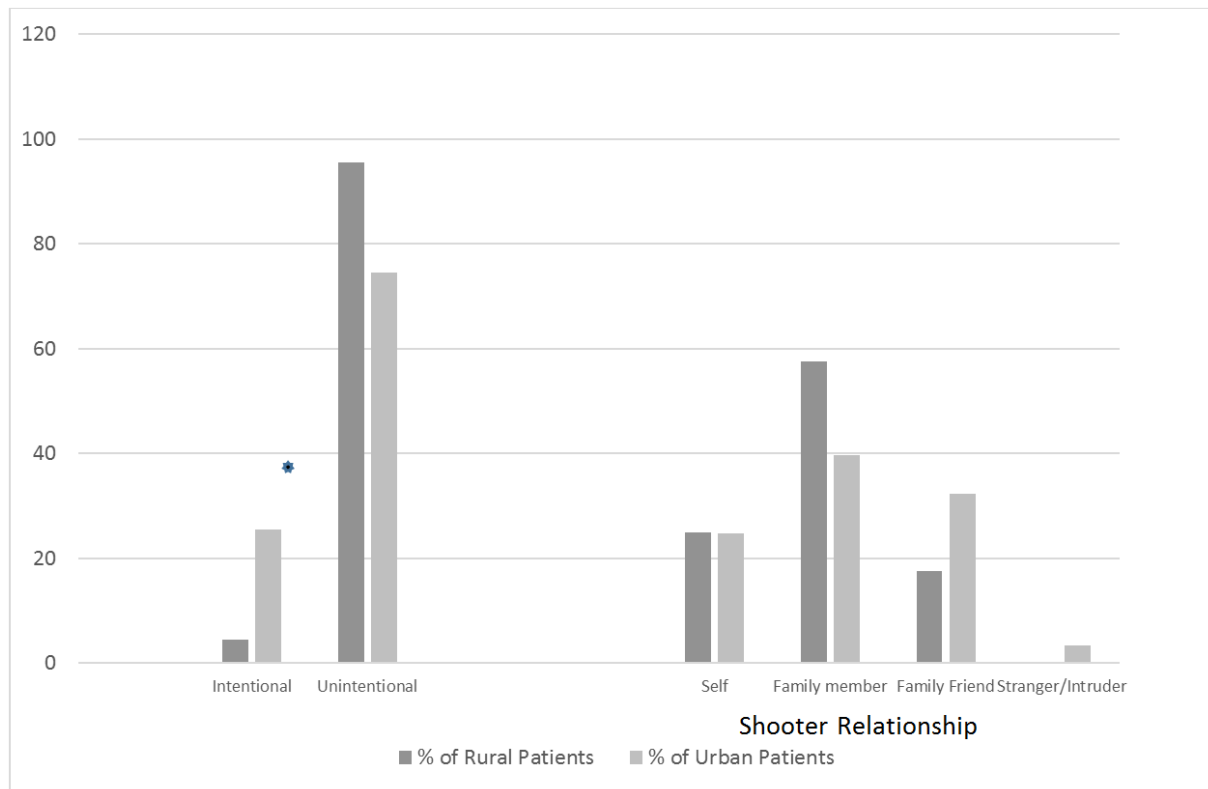
#### 3.4. Shooter Relationship

The shooter relationship was known in 75% ( $n=186$ ) of injuries. A majority of the shooters in both rural and urban areas were family members (57.5% and 39.7% respectively) (Figure 1). There was no statistically significant difference between rural and urban areas with regards to shooter relationship ( $p=0.112$ ). A significant difference exists between intentionality of the shooter and shooter relationship with intentional injuries 12.3 times more likely to be caused by a stranger/intruder than unintentional injuries (Table 2).

Table 2. Odds ratio of Race categories, Shooter relationship and Ballistic description by Intentionality.

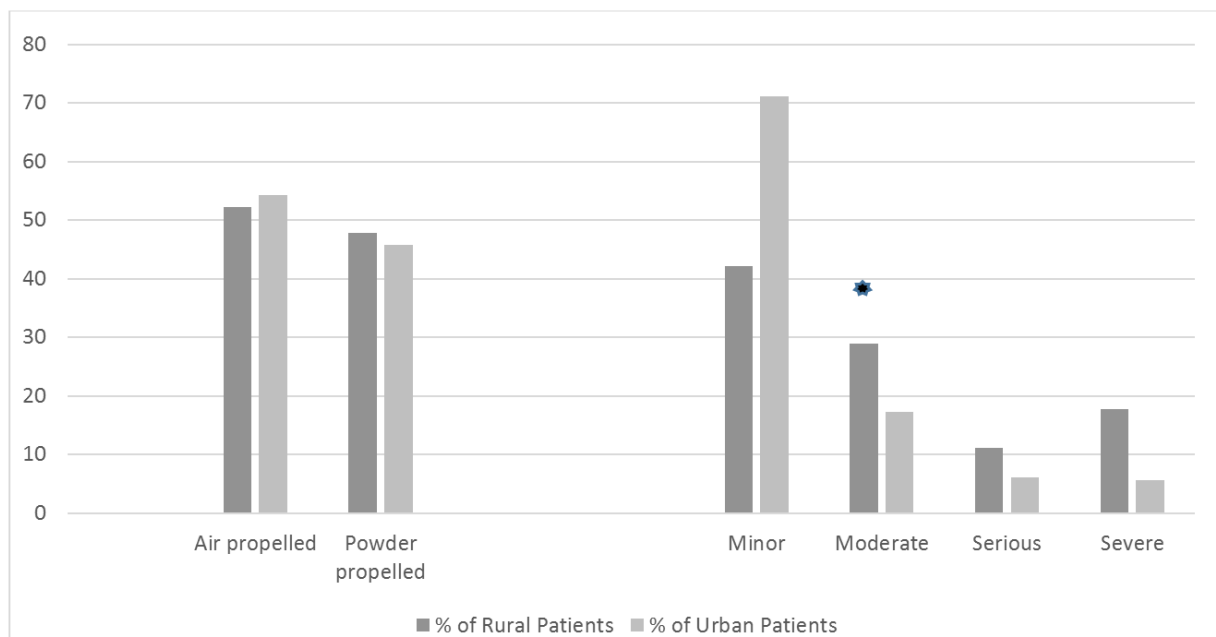
Variable	Intentionality		X <sup>2</sup> p-value	OR (CI)
	Unintentional	Intentional		
Shooter relationship			<0.0001	
Self (ref)	41 (25.3%)	5 (20.8%)		-
Family member	77 (47.5%)	4 (16.7%)		0.43 (0.11-1.67)
Family Friend	42 (25.9%)	12 (50%)		2.34 (0.76-7.24)
Stranger/Intruder	2 (1.2%)	3 (12.5%)		12.3 (1.64-92.32) *
Ballistics Description			<0.0001	
Air propelled (ref)	118 (63.8%)	8 (16.3%)		
Powder propelled	67 (36.2%)	41 (83.7%)		9.0 (4.0-20.4) *

\*p-value is significant at <0.05.



\*p-value is significant at <0.05.

**Figure 1.** Shooter relationship, Intentionality by Location (Rural vs Urban).



\*p-value is significant at <0.05.

**Figure 2.** Ballistic Type, Injury Severity Score by Location (Rural vs Urban).

### 3.5. Injury Severity Score

Injury severity score differed between urban and rural communities with the majority of urban (71.1%, n=140) and rural (42.2%, n=19) injuries being in the minor category. However, a higher percentage of rural injuries were in the

moderate (28.9%, n = 13), serious (11.1%, n=5) and severe categories (17.8%, n=8), compared to the urban injuries (17.3%, n=34, 6.1%, n=12, and 5.6%, n=11 respectively) (Figure 2). There was no statistically significant difference in the mean ISS score across all Race categories p=0.268 (Table 3).

**Table 3.** Race categories by Type of Firearm, Intentionality and Injury Severity Score.

Variable	Ballistic Description		Intentionality			Injury Severity Score (ISS)	
	Air propelled	Powder propelled	OR (95% CI)	Unintentional	Intentional	OR (95% CI)	ISS Score (Mean± SD) F (p-value)
Race							1.32 (0.268)
White (ref)	45 (35.2%)	28 (25.5%)	-	70 (37%)	4 (7.7%)	-	8.2 ±9.3
Black	19 (14.8%)	43 (39.1%)	3.6 (1.8-7.5) *	36 (19%)	28 (53.8%)	13.6 (4.4-41.8) *	7.8 ± 8.6
Hispanic	54 (42.2%)	32 (29.1%)	0.95 (0.5-1.8)	70 (37%)	16 (30.8%)	4.0 (1.3-12.6) *	5.8 ±7.4
Other	10 (7.8%)	7 (6.4%)	1.1 (0.4-3.3)	13 (6.9%)	4 (7.7%)	5.4 (1.2-24.3) *	6.1 ±7.7

\*p-value is significant at <0.05.

### 3.6. Race and Type of Firearm

Black patients sustained the most injuries (39.1%) from powder propelled firearms followed by Hispanic patients (29.1%). Hispanic patients sustained the most injuries from air propelled firearm (42.2%) followed by White patients (35.2%). There was a statistically significant difference in type of Ballistics by Race ( $p < 0.0001$ ) with black children 3.6 times (CI 1.8-7.5) more likely to sustain injuries from powder propelled firearms as compared to their white counterparts. (Table 3).

### 3.7. Race and Intentionality

Fifty-three percent of intentional firearm injuries occurred in black patients followed by 31% in Hispanic patients. White and Hispanic patients each represented 37% of unintentional firearm injuries. There was a statistically significant association between race and intentionality of firearm injuries ( $p < 0.0001$ ). Black (OR-13.6), Hispanic (OR-4.0) and Other race (OR-5.4) had higher odds of being victims of intentional firearm injuries as compared to White patients (Table 3).

### 3.8. Type of Firearm and Intentionality

Among unintentional injuries, 36% were due to powder propelled firearms vs 64% of intentional injuries (Table 2). There was a statistically significant difference in intentionality of shooter by the type of firearm with powder propelled firearm injuries more likely (OR-9.0) to be intentional as compared to air propelled firearm injuries.

## 4. Discussion

This study illustrates significant differences in pediatric firearm injuries between urban and rural environments presenting to a single Level I Trauma center in Texas. These differences include: intention, the ethnicity of the child injured, and the injury severity score. There are a few studies looking at RUCA codes in a single region describing different etiologies of pediatric firearm injuries [5]; and a national comprehensive study evaluating urban versus rural differences in patients hospitalized from pediatric firearm injuries [17]. However, there are no regional studies in the south nor comprehensive studies involving firearm patients seen in all

pediatric care settings looking at these differences. This study adds to the growing body of literature and understanding of occurrences surrounding firearm injuries in children.

A strong predominance of males as victims of firearms was demonstrated, not statistically different between urban and rural communities. These results are in-line with previous studies [2, 14]. This likely further supports that guns are often the subject of play and fascination in young boys and may lead to increased injuries [15].

This study highlights a younger age group than other pediatric firearm studies available. This data is not overshadowed by adolescent criminal activity and focuses on a potentially more vulnerable population. A similar study from Pennsylvania looking at state patterns of firearm injuries in rural versus urban areas in children had a higher percentage of adolescents in their population with a mean age of 16.5 years [5]. This is over 5 years older than this studies population as the institution involved in this study does not routinely see patients older than 15 likely accounting for higher percentages of unintentional injuries represented.

Several previous firearm injury prevention strategies have focused on urban injuries which have reported higher rates of assaults related to powder propelled firearms [5, 8, 13]. These types of injuries only account for 46% of the injuries seen in this study however of note black children were 3.6 times more likely to sustain injuries from powder propelled firearms than their white counterparts. Strategies such as removing illegal weapons off the street and targeting teen gang violence are important, but there is still a large population of children in both rural and urban areas at risk for firearm injury from other causes.

In this study, while there were more intentional injuries in the urban community versus rural the majority of injuries in both settings were unintentional (96% in rural, 75% in urban). The majority of injuries in both settings were caused most commonly by a family member and then the child themselves. The American Academy of Pediatrics has campaigned to eliminate firearms in the home or, at a minimum, reduce access to firearms by encouraging gun locks, and separating the ammunition from the firearm when storing. There remains a question on what age this training should take place. In this study, the youngest shooter was 2 years old. As investigated by Ngo et al in 2019, 46 articles regarding firearm injury screening and prevention were identified from 1985 to 2018 and in those

studies few evidence-based programs exist [21]. At this point programs have not employed rigorous designs or assessed behavioral (e.g. carriage) or injury-related firearm outcomes. Evidence-based prevention programs are highly needed in order to mitigate pediatric firearm morbidity and mortality and must be an area of focus for future firearm research.

Finally, there was a difference in injury severity score in urban versus rural communities. While minor injuries were the most common in urban versus rural communities, injuries in the rural areas had a higher percentage of moderate, serious, and severe categories respectively. This highlights a previously unknown vulnerable population of children in the rural community and a need for outreach and firearm prevention and education targeting this community.

The main limitation of this study is the difficulty in showing statistical significance to generalize to other regions. This study also has an inherent selection bias toward more serious firearm injuries not resulting in immediate death because this studies institution is the only level 1 pediatric trauma center serving North and East Texas. Fatal injuries are not represented and less serious rural injuries would likely have been treated locally at outside adult trauma centers and EDs. Despite this bias, this study population does adequately represent those children that sustained more severe injuries and thus represents children requiring significant medical intervention and resources.

## 5. Conclusion

This data supports firearm injuries are significantly different at the rural versus urban level, and prevention strategies may best be served by studying regional use and local patterns of injury to design specific community-driven prevention efforts. More research is needed in understanding the relationship between perceptions of firearm danger, patterns of firearm injury and use, education and practices related to storage, use and care of firearms, and appropriate strategies for safety training and partnership with advocates on both sides of the firearm discussion. Simply stating that one should not own a gun has been poorly received by gun-owning parents and has been ineffective in preventing harm to children. Better efforts are needed to determine effective means of preventing injuries that is objective and data driven, is well-received from both gun owners and non-gun owners alike, and that protect the health of children.

## Disclosure

The authors have no conflicts and declare no financial interest in any product or service mentioned in the manuscript including grants, equipment, medications, employment, gifts and honoraria. The authors have full access to all data and take full responsibility for the integrity and accuracy of the data analysis.

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