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Firearm suicide among youth in the United States, 2004–2015

Patricia G. Schnitzer[1] · **Heather K. Dykstra**[1] · **Theodore E. Trigylidas**[2] · **Richard Lichenstein**[3]

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Abstract Suicide is a leading cause of death among children in the United States; firearms cause 37% of these deaths. Research is needed to better understand firearm accessibility among youth at risk for suicide. We reviewed data from the National Fatality Review Case Reporting System (NFR-CRS). Firearm suicide deaths of children ages 10–18 occurring 2004 through 2015 with completed suicide-specific section were included. Children who had talked about, threatened or attempted suicide were identified as "Greater Risk" (GR). Odds ratios (OR) and 95% confidence intervals (95%CI) were calculated. Of the 2106 firearm suicide deaths, 1388 (66%) had a completed NFR-CRS suicide section. Of these, 36% (494/1388) met the criteria for GR. Firearms were less likely to be stored in a locked location for GR children [adjusted OR 0.62, (95%CI 0.49–0.98)]. Strategies to limit firearm access, particularly for GR youth, should be a focus of suicide prevention efforts.

Keywords Suicide · Firearms · Gun violence · Pediatrics · Prevention · Child death review

✉ Patricia G. Schnitzer
pschnitzer@outlook.com

[1] National Center for Fatality Review and Prevention, Michigan Public Health Institute, 2479 Woodlake Circle, Suite 340, Okemos, MI 48864, USA

[2] Division of Emergency Medicine, Department of Pediatrics, Children's National Medical Center, George Washington University School of Medicine and Health Sciences, Washington, DC, USA

[3] Department of Pediatrics, University of Maryland School of Medicine, Baltimore, MD, USA

Suicide remains a critical and preventable cause of death among youth in the United States (US); firearms play an important role in these deaths. The Web-based Injury Statistics Query and Reporting System (WISQARS) maintained by the Centers for Disease Control and Prevention reports 42% of suicide deaths occurring between 2004 and 2016 among children aged 10 to 19 years were caused by firearms (Centers for Disease Control and Prevention, 2018).

Household firearms account for a large proportion of firearm-related injuries. In the US, at least one firearm is present in 34% of households with children; 21% of households have at least 1 unlocked and loaded firearm; and 84% of firearms for suicide attempters and completers are stored in the victim's residence (Azrael et al., 2018; Grossman et al., 1999, 2005). Several studies have demonstrated the effectiveness of secure firearm storage in reducing self-inflicted firearm injuries, both suicide and unintentional injuries, among children and adolescents (Grossman et al., 2005; Webster et al., 2004; Cummings et al., 1997). However, little is known about firearm storage practices in households with children at Greater Risk for suicide and whether access to the firearms present is more likely to be restricted in these households. The few studies that have addressed these issues suggest that having a child with a history of self-harm or other suicide risk factors does not result in parents increased use of safe storage practices that would reduce access to firearms in the home (Scott et al., 2018; Simonetti et al., 2015, 2017).

Child death review (CDR) is a process in which a multidisciplinary team conducts a comprehensive, retrospective review of all known circumstances of a child's death. The goal of CDR is to better understand how and why children die in an effort to inform prevention and ultimately improve the health and safety of children. Each

state in the US has a CDR program. Although team membership may vary by state, key team members include representatives from the following agencies or professions: law enforcement, child protective services, prosecutor/district attorney, coroner/medical examiner, public health, medicine, and emergency medical services. Team members share information about the child, family, and circumstances surrounding the death during the review. This information is typically obtained from agency records and investigation reports. The National Center for Fatality Review and Prevention (NCFRP) is a national resource center providing training and technical assistance to CDR programs in the US. The NFRCP maintains the National Fatality Review-Case Reporting System (NFR-CRS), a web-based system that contains detailed information on factors contributing to a child's death, including questions specific to suicide and firearm safety precautions. The objectives of this study are to use the NFR-CRS data to describe the characteristics of children who died by suicide using firearms and to determine whether there were differences, particularly relative to firearm access, between children who had talked about, threatened, or attempted suicide prior to death, compared to those who had not.

Methods

The data for this analysis are from the NFR-CRS. The objectives, development, features, and limitations of the NFR-CRS have been described in detail elsewhere (Covington, 2011). The NFR-CRS provides a standardized mechanism for recording data obtained during the CDR process. Data collected include detailed information on the child, parents, circumstances of the death, death investigation, cause of death and presence of known risk factors. The system contains over 2600 data elements, although not all are pertinent to suicide deaths. Data are entered into the system by a CDR team member who attended the death review. The NFR-CRS was created in 2005 (as the Child Death Review Case reporting system) and piloted in 19 states. Currently 45 states use the NFR-CRS; each participating state has a data use agreement with the NCFRP. A copy of the report form is available at https://www.ncfrp.org/resources/national-cdr-case-reporting-system/#CRS.

The study population includes children age 10 through 18 years, who died between January 1, 2004 and December 31, 2015, for whom the manner of death was identified as suicide on the death certificate, and the cause of death recorded in the NFR-CRS was weapon/firearm (n = 2106). The NFR-CRS contains detailed questions on suicide risk factors, suicidal ideation, previous suicide attempts, and circumstances of suicide deaths. However, prior to April 2018, navigation to this suicide-specific section was not direct and, as a result, the questions were not answered for all suicide deaths during the period under study. For this study, only those youth with a completed suicide-specific section were included (n = 1388). Deaths from 34 states met the inclusion criteria.

The suicide-specific section, which is completed based on information shared during the death review, contains questions as to whether the child had talked about suicide, made threats of suicide, or attempted suicide in the past. Among the 1388 firearm suicides meeting our study criteria, we defined youth for whom the child death review team had documented that the youth had previously talked about, threatened, or attempted suicide as "Greater Risk" for suicide (n = 494); youth who had not talked about, threatened, or made prior suicide attempt(s) were defined "Not Greater Risk" (n = 894). We examined covariates in the NFR-CRS that might influence suicide risk: child characteristics, details of the incident, and firearm characteristics. In this study population of children who completed suicide with a firearm, we compared children in the Greater Risk for suicide category (as defined here) with those in the Not Greater Risk group and assessed whether firearm access was more likely to be limited for children in the Greater Risk group. We used the NFR-CRS question "Where was firearm stored?" to indicate access. The response options for this question are not stored, locked cabinet, unlocked cabinet, glove compartment, under mattress/pillow, other. We coded all responses where storage was indicated in a locked cabinet as such. All other response options were classified as "not locked."

Data analysis

Frequencies and proportions were generated for child, incident, and firearm characteristics stratified by Greater Risk versus Not Greater Risk. We calculated odds ratios (ORs) and 95 percent confidence intervals (95% CIs) to assess the association between Greater Risk categories and each covariate of interest. Chi squared analyses were performed to assess whether the Greater Risk group differed significantly ($\alpha = 0.05$) for each covariate.

We conducted multivariate logistic regression analysis and calculated OR and 95% CIs to assess the association between firearm access and Greater Risk for suicide, while controlling for year of death and state. Covariates significantly associated with Greater Risk were selected for confounding assessment. We considered a variable a confounder if its inclusion in a logistic regression model with firearm access, year of death, and state as independent variables resulted in a change of the effect estimate of $\geq$ 10% (Rothman & Greenland, 1998). Variables meeting this criterion were: child sex, history of chronic disease or

disability, and experiencing a barrier to receiving mental health services. Finally, we conducted multivariate logistic regression to assess the association of firearm access with Greater Risk while controlling for year of death, state, and confounding variables.

Several covariates, including the firearm storage variable, had missing data. Because records with missing data are excluded from regression analyses, imputation of missing values may produce less biased estimates and is recommended. In preparation for conducting the final multivariate logistic regression analysis, we used multiple imputation (Fully Conditional Specification; 60 iterations) to estimate missing values. Variables for which missing values were imputed are identified in Table 1. All analyses were completed using SPSS v25.

Results

Of the 1388 children age 10 through 18 years who completed suicide using a firearm, 1058 (76%) were 15–18 years old (mean 15.6 years), 1175 (85%) were male, and 1034 (75%) were white, non-Hispanic. The suicide took place in the home of the child or a relative in 1105 (80%) of the deaths, with 1003 (72%) of these in the child's home. The firearm used belonged to the child in 129 deaths (9%) or to the child's parent or other relative in 825 deaths (59%); the owner was unknown for 286 deaths (21%). Of suicides that occurred in the child's home (n = 1003), the owner of the gun was known for 761; this owner was either the child or a parent for 90% of these deaths (683/761). The majority (60%) of the suicides were completed using a handgun. Only 153 (11%) of the firearms were stored in a locked cabinet and 128 (9%) were documented to have at least one safety feature (e.g., trigger lock).

Four hundred ninety-four of the children (36%) had talked about, threatened or attempted suicide prior to their death (Greater Risk group). Children in the Greater Risk group were significantly more likely than those in the Not Greater Risk group to have a history of child maltreatment, have a disability or chronic illness, have problems in school, have received mental health services, be on medications for mental health, have experienced a barrier to receiving mental health services, have histories of substance abuse or criminal activity, and have spent time in juvenile detention (Table 1). They were also more likely to have used drugs or alcohol prior to completing suicide and were less likely to be male. There were no significant differences in firearm characteristics among the Greater Risk group compared with the Not Greater Risk group (Table 1).

Although there were considerable missing data for the gun storage variables (whether the gun was stored locked, stored with ammunition, stored loaded), 340 (25%) of the 1388 firearm suicide deaths had all three questions completed. Of these, 47% (161/340) had the most hazardous access: gun stored unlocked, loaded, and with ammunition; and of these, 38% (61/161) were in the Greater Risk group. More than one-third of the 61 Greater Risk youth with the most hazardous access to firearms had attempted suicide on a previous occasion.

Logistic regression analysis revealed that firearms used in these youth suicides were less likely to be stored in a locked cabinet for children in the Greater Risk group (Table 2). After controlling for confounders as well as year of death and state, this association was statistically significant (OR 0.69; 95% CI 0.49–0.98; $p = 0.04$).

Discussion

Contrary to what might be expected, we found that firearms used by children who had died by suicide who had previously talked about, threatened or attempted suicide were less likely to be stored in a locked location than firearms used by children who had not talked about, threatened or attempted suicide. Scott et al. (2018) documented that a similar proportion of households with children in residence stored guns locked and unloaded (approximately 1 in 3) regardless of whether they had a child with a history of self-harm risk factors or not. Those authors concluded that having a child with self-harm risk factors (depression, attention deficit hyperactivity disorder, other mental health issues) did not appear to alter the parent's decision to have firearms in the home, nor influence limiting access by storing the firearms locked and unloaded (Scott et al., 2018). Simonetti et al. (2017) also found no differences in firearm storage practices in households of adolescents with mental illness compared to households of adolescents without mental illness. Similarly, an analysis of a nationally representative survey of adolescents concluded that adolescents with risk factors for suicide were equally likely to report easy access to firearms at home as adolescents without suicide risk factors (Simonetti et al., 2015). Our study, unique in that we had information on how the firearm used by a youth to complete suicide was stored, adds to this growing body of literature that documents failure to restrict access to firearms in homes with children, even when the children have documented risk factors for suicide.

Research has shown that having a firearm in the home is associated with increased risk of adolescent suicide (Brent et al., 1991, 1993), and that storing firearms locked and unloaded reduces that risk of suicide among youth (Grossman et al., 2005). The evidence of having an accessible gun in the home and increased risk of suicide among youth is compelling enough that the American

Table 1 Child, incident, and firearm characteristics by Greater Risk versus Not Greater Risk, firearm suicides, 2004–2015, National Fatality Review-Case Reporting System

	Firearm risk group			
	Greater Risk N = 494 (%)	Not Greater Risk N = 894 (%)	OR (95% CI)	*P* value
Child characteristics				
Age category				
10–14 years	108 (21.9)	222 (24.8)	Reference	0.21
15–18 years	386 (78.1)	672 (75.2)	1.2 (0.9–1.5)	
(missing, n = 0)				
Mean age (SD)	15.6 (1.5)	15.5 (1.6)		
Sex				
Male	382 (77.5)	793 (88.9)	0.4 (0.3–0.6)	< 0.01
Female	111 (22.5)	99 (11.1)	Reference	
(missing, n = 3)				
Race/ethnicity				
Non-hispanic white	372 (75.3)	662 (74.0)	Reference	0.19
Non-hispanic black	31 (6.3)	73 (8.2)	0.7 (0.5–1.2)	
Hispanic	58 (11.7)	111 (12.4)	0.9 (0.7–1.3)	
Other	25 (5.1)	28 (3.1)	1.6 (0.9–2.8)	
(missing, n = 28)				
Open CPS case at time of death?				
Yes	21 (5.2)	22 (3.2)	1.6 (0.9–3.0)	0.12
No	385 (94.8)	665 (98.8)	Reference	
(missing, n = 295)				
[a]History of child maltreatment				
Yes	130 (38.2)	117 (22.1)	2.2 (1.6–2.9)	< 0.01
No	210 (61.8)	412 (77.9)	Reference	
(missing, n = 519)				
[a]Child had disability or chronic illness?				
Yes	131 (34.9)	123 (19.7)	2.2 (1.6–2.9)	< 0.01
No	244 (65.1)	502 (80.3)	Reference	
(missing, n = 388)				
Child ever placed outside of home?				
Yes	42 (11.2)	49 (8.0)	1.5 (0.9–2.2)	0.09
No	332 (88.8)	562 (92.0)	Reference	
(missing, n = 403)				
Child's residence				
Child's/relative's home	469 (97.7)	827 (98.0)	(0.5–2.5)	0.74
Other	11 (2.3)	17 (2.0)	Reference	
(missing, n = 64)				
[a]Child have problems in school?				
Yes	172 (60.6)	233 (47.0)	1.7 (1.3–2.3)	< 0.01
No	112 (39.4)	263 (53.0)	Reference	
(missing, n = 608)				
[a]Had child received mental health services?				
Yes	228 (66.3)	153 (33.0)	4.0 (3.0–5.4)	< 0.01
No	116 (33.7)	310 (67.0)	Reference	
(missing, n = 581)				

Table 1 continued

	Firearm risk group			
	Greater Risk N = 494 (%)	Not Greater Risk N = 894 (%)	OR (95% CI)	*P* value
[a]Currently receiving mental health services?				
Yes	112 (37.2)	72 (16.3)	3.0 (2.2–4.3)	< 0.01
No	189 (62.8)	369 (83.7)	Reference	
(missing, n = 646)				
[a]Child on meds for mental health issue?				
Yes	99 (31.8)	53 (12.0)	3.4 (2.4–5.0)	< 0.01
No	212 (68.2)	390 (88.0)	Reference	
(missing, n = 634)				
[a]Barrier to receiving mental health services?				
Yes	28 (12.6)	18 (4.9)	2.8 (1.5–5.2)	< 0.01
No	194 (87.4)	350 (95.1)	Reference	
(missing, n = 798)				
[a]Child history of substance abuse?				
Yes	156 (48.4)	162 (32.0)	2.0 (1.5–2.7)	< 0.01
No	166 (51.6)	345 (68.0)	Reference	
(missing, n = 559)				
[a]Child delinquent or criminal history?				
Yes	94 (28.3)	105 (18.3)	1.8 (1.3–2.4)	< 0.01
No	238 (71.7)	470 (81.7)	Reference	
(missing, n = 481)				
[a]Child spent time in juvenile detention?				
Yes	35 (10.9)	28 (5.3)	2.2 (1.3–3.7)	< 0.01
No	287 (89.1)	504 (94.7)	Reference	
(missing, n = 534)				
Incident Characteristics				
Incident place				
Child's or relative's home	400 (81.0)	705 (80.5)	0.9 (0.7–1.2)	0.55
Other place	89 (18.2)	171 (19.5)	Reference	
(missing, n = 23)				
Type of area				
Urban/suburban	313 (66.7)	550 (66.7)	1.0 (0.8–1.3)	0.99
Rural/frontier	156 (33.3)	274 (33.3)	Reference	
(missing, n = 95)				
[a]Had child used drugs/alcohol prior to incident?				
Yes	96 (28.2)	116 (19.6)	1.6 (1.2–2.2)	< 0.01
No	244 (71.8)	475 (80.4)	Reference	
(missing, n = 457)				
Firearm Characteristics				
[a]Type of firearm				
Handgun	308 (64.8)	519 (62.3)	1.1 (0.9–1.4)	0.36
Other gun	167 (35.2)	314 (37.7)	Reference	
(missing, n = 80)				
[a]Owner of firearm				
Child/self	40 (10.4)	89 (13.7)	0.7 (0.5–1.1)	0.12
Other person	346 (89.6)	563 (86.3)	Reference	
(missing, n = 350)				

Table 1 continued

	Firearm risk group			
	Greater Risk N = 494 (%)	Not Greater Risk N = 894 (%)	OR (95% CI)	*P* value
[a]Was firearm stored in locked cabinet?				
Not locked	254 (79.6)	415 (82.5)	0.8 (0.6–1.2)	0.30
Locked cabinet	65 (20.4)	88 (17.5)	Reference	
(missing, n = 566)				
Firearm stored with ammunition?				
Yes	146 (75.3)	246 (77.1)	0.9 (0.6–1.4)	0.63
No	48 (24.7)	73 (22.9)	Reference	
(missing, n = 875)				
Firearm stored loaded?				
Yes	84 (49.1)	142 (55.3)	0.8 (0.5–1.2)	0.21
No	87 (50.9)	115 (44.7)	Reference	
(missing, n = 960)				

[a]Designates variables for which multiple imputation was used to estimate missing values

Table 2 Estimates of firearm stored in locked cabinet versus not locked by Greater Risk versus Not Greater Risk, firearm suicides, 2004–2015, National Fatality Review-Case Reporting System

Logistic regression analysis	OR (95% CI)	*P* value
Un-pooled[a]	0.82 (0.57–1.17)	0.27
Pooled[b]	0.80 (0.57–1.12)	0.19
Pooled, control for confounding[c]	0.69 (0.49–0.98)	0.04

[a]Adjusted for year of death and state

[b]Multiple imputation to estimate missing values; adjusted for year of death and state

[c]Multiple imputation to estimate missing values; adjusted for year of death, state, sex, history of chronic disease or disability, barrier to receiving mental health services

Academy of Pediatrics recommends that health care professionals counsel parents of adolescents to remove guns from the home or restrict access to them, particularly if the child has a history of mood disorders, substance abuse problems, or suicide attempts (Dowd & Sege, 2012). However, research demonstrates that parents with children older than 12 are more likely to have firearms stored unsafely (Johnson et al., 2006). A recent nationally representative survey of gun owners in households with children documented that 20% of these households have at least one gun stored unlocked and loaded while 50% have at least one gun locked and loaded or unlocked and unloaded (Azrael et al., 2018). In another study of households with guns, 73% of children ages 5 through 14 years old can locate guns and 36% have handled the weapons (Baxley & Miller, 2006). In our study of firearm suicides, when the suicide occurred in the child's home, 90% of the firearms used were known to be owned by the child or child's parent; only 11% were stored locked, and firearms used by children in the Greater Risk group were less likely to be stored locked than firearm used by children in the Not Greater Risk group.

There are potential limitations to our study, primarily related to limitations inherent in the NFR-CRS data. Although every state has a child death review program, these programs can vary considerably in the process for the reviews, including the level of the review (state, local), the types of deaths reviewed, and whether the process is voluntary or mandated (Webster et al., 2003). Similarly, participation in the NFR-CRS is voluntary and data quality assurance, including assessing accuracy and completeness of data elements varies across states. For example, the suicide specific section was not completed for one-third of the firearm suicide deaths. To assess whether these missing data may have biased our results, we compared data between the two groups, those with the suicide section complete and those without, to assess whether there were any important differences. There were no differences in age,

sex, or race distribution across the two groups; however, deaths without the suicide section completed tended to have higher proportions of missing data for other covariates as well. Consequently, we suspect these missing data reflect differences in the CDR programs or process (e.g., incomplete death investigation, information not made available during the review) rather than differences in the suicide deaths or decedents, but we are not able to assess this more fully. Finally, for this analysis, 34 states had deaths entered that met our inclusion criteria. These states may not be representative of firearm suicide deaths in all 50 states.

Despite these potential limitations, our study has some important strengths. We had data on a large number of youth firearm suicides, including a level of detail on suicide risk factors that permitted classification based on whether the youth had talked about, threatened or attempted suicide in the past. The NFR-CRS also contains information on many other risk factors for suicide that are not available in other sources of mortality data, including mental health issues, substance abuse, and history of child maltreatment or chronic disease/disability. Access to this risk factor information permitted identification of and control for potential confounding variables. Finally, we imputed missing data which allowed inclusion of all 1388 firearm suicide deaths in our logistic regression analysis.

Access to firearms is an important risk factor for youth suicide, as it makes a highly lethal method available to a highly impulsive age group. Restricting access to firearms, a documented strategy for reducing suicide, should be a focus of youth suicide prevention efforts.

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Compliance with ethical standards

Conflict of interest Patricia G. Schnitzer, Heather K. Dykstra, Theodore E. Trigylidas and Richard Lichenstein declare that they have no conflict of interest.

Human and animal rights and Informed consent This study did not include living human participants or animals. For this type of study (retrospective analysis of secondary data on deceased children) formal consent is not required.

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