

ORIGINAL ARTICLE

Risk factors associated with non-fatal adolescent firearm injuries

C A Paris, E A Edgerton, M Sifuentes, J S Seidel, R J Lewis, M Gausche

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See end of article for authors' affiliations

Correspondence and reprint requests to: Dr Carolyn A Paris, Division of Pediatric Emergency Medicine, Children's Hospital and Regional Medical Center, 4800 Sand Point Way NE, P O Box 5371/CH-04, Seattle, WA 98105, USA; cparis@chmc.org

Study objective: To identify behavioral, environmental, and sociodemographic risk factors associated with non-fatal firearm injuries among inner city adolescents in the United States.

Design: A case-control study in which patients with firearm injury serve as cases and those with medical conditions serve as controls.

Setting: A level I trauma center in a metropolitan area serving a predominately lower socioeconomic status population.

Participants: Cases were 45 consecutive patients 11–18 years presenting to the emergency department with a non-fatal firearm injury; controls were 50 age and gender matched patients presenting with acute medical problems.

Outcome measure: Odds ratios (OR) and associated 95% confidence intervals (CI) as estimates of the magnitude of association between risk factors and non-fatal firearm injury.

Results: After adjusting for age, gender and socioeconomic status, multivariate analysis identified four risk factors independently associated with firearm injury: living with less than two parents (OR 3.8, 95% CI 1.2 to 12.2), skipping class (OR 7.1, 95% CI 1.7 to 28.9), previous arrest (OR 6.2, 95% CI 1.9 to 20.7), and being African-American (OR 4.2; 95% CI 1.4 to 14.9).

Conclusion: Risk factors for adolescents sustaining a non-fatal firearm injury are sociodemographic and environmental, not just behavioral. Thus interventions that foster protective and supportive environments may help prevent firearm injuries.

In 1998, the US firearm death rate for children 0–14 was 1.1 deaths per 100 000 and for those 5–19 was 16.3 per 100 000.¹ Epidemiologic studies have searched for associations between patterns of behavior and firearm injuries, as well as other adverse health outcomes. Among adolescents, risk taking or problem behaviors such as substance abuse, gang membership, and early initiation of sexual activity have been associated with health consequences such as homelessness, pregnancy, and suicide.^{2–8} Such studies provide a framework linking behavioral factors with health outcomes and seek to place them in a larger social context. We hypothesized that the risk of firearm injury is related to environmental and sociodemographic characteristics, in addition to behavioral factors.

METHODS

Design and participants

This case-control study was conducted at a level I trauma center in a major metropolitan area that serves a population of lower socioeconomic status. Cases were 45 patients ages 11–18 years presenting to the emergency department with a non-fatal firearm related injury, except those whose injuries were from an air powered BB or pellet gun. Fifty controls were selected from patients presenting with a medical problem, excluding those with chronic conditions, and matched to cases by gender and age (within one year).

The Institutional Review Board approved the study with a waiver of parental consent; verbal assent was obtained from all subjects.

Data collection

To assess behavioral and psychosocial risk factors we developed a measure from an adolescent risk profile interview known by the acronym HEADSS.^{5–8} The acronym denotes six significant areas of risk: **H**ome environment, **E**ducational

habits or employment status, peer group related **A**ctivities, **D**rug use, **S**exual activity, and **S**uicide or depressive tendencies. We added questions regarding socioeconomic status, access to guns, and exposure to violence and estimated income as a proxy for socioeconomic status from 1990 US census data for the postal code of residence.⁹ The 60 standardized questions (see box 1) were administered by four of the authors (CP, EE, MS, MG) trained in this technique. Subjects were interviewed within 48 hours of being seen in the emergency department.

Statistical analysis

Cases and controls were first compared using univariate analysis of each variable to which at least 75% of the subjects responded. Variables with a Likert scale response were dichotomized near the median response. Statistical significance was assessed using χ^2 , Fisher's exact, or Wilcoxon rank sum test statistics, as appropriate. Results are presented as odds ratios (OR) with 95% confidence intervals (CI). To determine which variables to include in a multivariate regression, variables within each HEADSS domain were first analyzed using forward stepwise logistic regression and those with a p value ≤ 0.1 from each domain specific logistic regression were retained. The final model was arrived at using a backward stepwise procedure, using variables from the second multivariate logistic regression. Age, gender, and postal code derived median income were forced into the final model to adjust for residual confounding. The final model was assessed with a Hosmer-Lemeshow goodness-of-fit test, and evaluated for the predictive value of determining case status using a

Abbreviations: CI, confidence interval; HEADSS, home environment, educational habits or employment status, peer group related activities, drug use, sexual activity, and suicide; OR, odds ratio

Box 1: Examples of interview questions, derived from the HEADSS psychosocial risk assessment instrument⁹ with additional domains labeled "sociodemographics" and "safety"

Home

- Who do you live with?
- Do you live in a house or an apartment?
- Do you feel safe walking down your street?

Education

- Are you currently in school?
- Have you ever repeated a grade in school?
- Have you ever been suspended or expelled from school?

Activities

- When you are at home, how often is an adult present?
- How often do you hang out with your friends?
- Are you in a gang or do you know anyone in a gang?
- Have you ever been arrested or gone to prison?

Drugs

- Do any of your friends use drugs?
- Have you ever tried drugs?
- Have you ever performed favors to get drugs?
- Do you think you or anyone in your family has a problem with drugs?

Sex

- Are you attracted to men, women, or both men and women?
- Have you ever been sexually active?
- Have you ever been or gotten someone pregnant?

Suicide/depression

- Do you ever feel sad, alone, or like no one cares about you?
- Have you ever thought about hurting yourself?
- Have you ever tried to kill yourself?

Safety

- Do you have a gun in your home?
- Do you know anyone who has been injured or killed by a firearm?
- Have you witnessed any violent crimes?
- Have you, or anyone in your family, ever been sexually or physically abused?

Sociodemographics

- What race/ethnicity would you use to describe yourself?
- What would you estimate is your family's monthly income?
- What was the last grade your mother completed in school?

receiver operating characteristic curve. STATA Statistical Software (Stata Corporation, College Station, Texas) was used to perform all analyses.

RESULTS

Most shootings involved a handgun (82%), occurred in the evening (70%), on a weekend (61%), and were assaults by strangers (59%) (table 1). There was a significant difference in ethnicity between cases and controls, with African-American youth representing a larger proportion of the cases, 49% versus 14% (table 2).

Univariate associations for each variable are presented (table 3). In the final model, four factors were independently associated with non-fatal firearm related injury after adjusting for age, gender, and socioeconomic status (table 4). These included youth living at home with a single parent, skipping class, having been arrested, and being African-American.

DISCUSSION

We identified several risk factors that distinguished adolescents sustaining a non-fatal firearm injury from age and gender matched controls. The four factors were not living with both parents, skipping class, having been arrested, and being

Table 1 Event characteristics reported by firearm related injury patients

Characteristic	No (%)
Day of event	
Weekday	17 (39)
Weekend	27 (61)
Firearm type	
Handgun	37 (82)
Shotgun	2 (4)
Assault weapon	1 (2)
Unknown	5 (11)
Circumstance	
Suicide	1 (2)
Assault	24 (53)
Unintentional, self	2 (4)
Unintentional, other	15 (33)
Unknown	3 (7)
Perpetrator	
Self	3 (7)
Acquaintance	7 (6)
Stranger	26 (59)
Not seen	8 (18)

*Totals may not add up to 45 because of missing data.

Table 2 Demographic characteristics of cases and controls*

	No (%) cases (n=45)	No (%) controls (n=50)
Age (years)		
11–13	9 (20)	14 (28)
14–18	36 (80)	36 (72)
Sex		
Male	40 (89)	44 (88)
Female	5 (11)	6 (12)
Race/ethnicity†		
African-American	22 (49)	7 (14)
Hispanic	20 (44)	39 (78)
Other	3 (7)	4 (8)

*Cases and controls were frequency matched by age and gender, but were not matched by self reported ethnicity or race.
† χ^2 $p < 0.004$.

African-American. These results suggest that sociodemographic and environmental factors each contribute to a youth's risk for firearm injury, and that consideration of individual behavioral factors alone may fail to identify important risk factors.

The demographic characteristics and firearm injury circumstances experienced by the cases in this study were similar to those reported in previous studies. For example, in our study 54% were due to assault compared with 52%–60% in other studies.^{10–11} Similarly, most studies, like ours, report that the majority were caused by handguns.^{12–15} However, in contrast, we found that the perpetrator was more frequently a stranger than previously reported. This may be because older adolescents are less likely to know their assailant than younger children.^{1–11}

Previous studies have concentrated on risk taking or problem behaviors, such as drug use and sexual activity. Few studies have investigated the association of these behaviors with firearm injury.¹⁶ Moreover, many earlier studies are limited by their reliance on self reported behaviors for both the exposure and the outcome or preferentially emphasize problem behaviors. In contrast, the risk factors we found to be independently associated with firearm injury support the hypothesis that firearm injury is associated with environmental and socio-demographic characteristics, in addition to problem behaviors.

In the only prior case-control study of adolescent non-fatal firearm injuries, Laraque *et al* reported injury risk factors among 26 gun shot wound patients and 34 control patients

Table 3 Univariate odds ratios as estimates of relative risk of firearm related injury in cases compared with controls

Risk factor	No (%) cases (n=45)	No (%) controls (n=50)	OR (95% CI)
Home			
<2 parents*	26 (58)	13 (26)	3.9 (1.6 to 9.3)
Unsafe home street	22 (49)	15 (30)	2.2 (1.0 to 5.2)
Family homeless	3 (7)	0 (0)	2.2 (1.8 to 2.7)
Runaway from home	11 (24)	6 (12)	2.4 (0.8 to 7.1)
Live in a house	30 (67)	29 (58)	1.4 (0.6 to 3.3)
Education			
Skip class*	20 (44)	5 (10)	7.2 (2.4 to 21.5)
Missed any days	20 (44)	10 (20)	3.4 (1.4 to 8.4)
Fail class	38 (84)	30 (60)	3.6 (1.4 to 9.7)
Suspension*	38 (84)	24 (48)	5.9 (2.2 to 15.6)
Expulsion	15 (33)	4 (8)	5.8 (1.7 to 19)
Not enrolled	9 (20)	1 (2)	12.3 (1.5 to 101)
Repeated a grade	6 (13)	6 (12)	1.1 (0.3 to 3.8)
Job counseling	29 (64)	29 (58)	1.3 (0.6 to 3.0)
Activities			
Home alone	19 (43)	9 (18)	3.5 (1.4 to 8.7)
Hang out	29 (66)	21 (44)	2.5 (1.1 to 5.7)
Watch TV more	41 (93)	35 (70)	5.9 (1.7 to 20.4)
Arrest*	26 (58)	7 (14)	8.4 (3.1 to 22.7)
Prison	8 (18)	1 (2)	10.6 (1.3 to 88.5)
In a gang	13 (28)	6 (12)	3.0 (1.0 to 8.7)
Know a gang	39 (87)	35 (70)	2.8 (1.0 to 8.0)
No support person	7 (16)	4 (8)	2.1 (0.6 to 7.8)
Drugs			
Any drug use*	25 (58)	9 (18)	6.3 (2.5 to 16.2)
Alcohol	34 (79)	23 (46)	4.4 (1.8 to 11.1)
Marijuana	23 (53)	9 (18)	5.2 (2.1 to 13.4)
Amphetamine	6 (14)	0 (0)	2.4 (1.8 to 3.0)
Family member with drug problem	15 (33)	11 (22)	1.7 (0.7 to 4.3)
Sex			
Sexually active*	29 (66)	9 (18)	8.8 (3.4 to 22.6)
Pregnancy	4 (14)	0 (0)	1.3 (1.1 to 1.6)
Suicide			
Depression	8 (18)	3 (6)	3.5 (0.9 to 14.1)
Suicidal ideation	7 (16)	5 (10)	1.7 (0.5 to 5.8)
Safety			
Know gun owner*	35 (78)	24 (48)	3.8 (1.5 to 9.3)
Know gun injury*	40 (89)	29 (58)	5.8 (2.0 to 17.2)
Know gun fatality	17 (38)	16 (32)	1.3 (0.6 to 3.0)
Fired a gun	21 (48)	11 (22)	3.2 (1.3 to 7.9)
Gun in the home	8 (18)	6 (12)	1.6 (0.5 to 5.1)
Victim of violence	11 (25)	6 (12)	2.4 (0.8 to 7.3)
Victim of violence, family member	11 (25)	5 (10)	3.0 (1.0 to 9.5)
Witness crime	28 (62)	23 (46)	1.9 (0.9 to 4.4)
Gun use instruction	28 (62)	35 (70)	0.7 (0.3 to 1.7)

*A forward stepwise logistic regression was performed on each HEADSS domain, and the variables with $p < 0.10$ (marked with asterisks above) were entered into the final multivariate logistic model.

Table 4 Multivariate odds ratios as estimates of relative risk of firearm related injury in cases compared with controls, for factors significant at the $p \leq 0.05$ level*

Risk factor	OR (95% CI)
Less than 2 parents in the home	3.8 (1.2 to 12.2)
Skipping class	7.1 (1.7 to 28.9)
Prior arrest	6.2 (1.9 to 20.7)
African-American race	4.2 (1.2 to 14.9)

*Estimates are adjusted for age, gender, and socioeconomic status.

including living without a parent, experiencing parental death, dropping out of school, or knowing a gun injury victim.¹⁶ Although there are limited data on the selection criteria, factors investigated, or demographic characteristics of these subjects, we note similar findings.

Limitations

Potential limitations of this study include selection bias, information bias (accuracy), confounding, and small sample

size. To avoid selection bias, we only included subjects from our public hospital and both cases and controls were drawn from similar neighborhoods close to the hospital. This restriction limits generalizability but as firearm injury is more common among the poor, the restriction seems justified. Information bias may lead to incorrect inferences if either cases or controls were less likely to give accurate responses. For example, a larger fraction of controls than cases were Hispanic and it is possible that language comprehension differed between the groups. Similarly, problem behavior questions may have seemed more threatening to someone with a recent firearm injury (the cases), and thus more prone to inaccurate responses than for controls.

Confounding occurs when an observed association between exposure and outcome is distorted by association with an extraneous exposure; that is, the apparent effect of the exposure under study is influenced by a "confounder". For example, African-American race was found to be strongly related to firearm injury, despite inclusion of other sociodemographic characteristics. It is possible, however, that further adjustment for currently unmeasured environmental and community level attributes might reduce the risk associated with African-American race. Powell and Tanz found that while poverty and

Key points

- Independent risk factors for adolescent non-fatal firearm injury in this study were: living with less than two parents, skipping class, prior arrest, and African-American race.
- Consideration of sociodemographic and environmental risk factors, in addition to the more traditionally evaluated behavioral factors, will lead to a more complete understanding of the adolescent risk profile for firearm injury.
- Successful firearm injury prevention is most likely to follow interventions that foster protective and supportive environments.

black race are highly correlated and accounted for most of the variance in community assault rates, they were unable to separate the effects of race and poverty on firearm injury.¹⁵ They hypothesized that community specific differences in housing and population densities, family disruption, police and gang presence, illegal drug trading, and firearm density all contribute to violent events, but could not be measured in their study.¹⁵

Our study is also limited by its small sample. This decreased our ability to precisely estimate the effect of specific risk factors. Finally, the small sample prohibited analysis stratified by mechanism and may have limited our ability to demonstrate associations with uncommon exposures.

IMPLICATIONS FOR PREVENTION

The identified associations contribute to an understanding of the underlying causes of firearm related injuries by identifying risk factors that are sociodemographic and environmental, as well as behavioral. Together these risk factors were strongly predictive of firearm injury (receiver operating characteristic curve = 0.87) among our population. If this is replicated the measure we used might serve as a screening tool in the emergency department to identify high risk individuals as targets for prevention measures. The findings suggest that prevention measures should seek not only to reduce problem behaviors, but also to foster protective and supportive environments for youth.

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Authors' affiliations

C A Paris, Division of Pediatric Emergency Medicine, Department of Pediatrics, Children's Hospital and Regional Medical Center, Seattle, Washington and Department of Pediatrics, Harbor-UCLA Medical Center, Torrance, California
E A Edgerton, M Sifuentes, Department of Pediatrics, Harbor-UCLA Medical Center, Torrance, California
J S Seidel, Departments of Pediatrics and Emergency Medicine, Harbor-UCLA Medical Center, Torrance, California
R J Lewis, M Gausche, Department of Emergency Medicine, Harbor-UCLA Medical Center, Torrance, California

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