Gun Storage Practices and Risk of Youth Suicide and Unintentional Firearm Injuries

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Context Household firearms are associated with an elevated risk of firearm death to occupants in the home. Many organizations and health authorities advocate locking firearms and ammunition to prevent access to guns by children and adolescents. The association of these firearm storage practices with the reduction of firearm injury risk is unclear.

Objective To measure the association of specific household firearm storage practices (locking guns, locking ammunition, keeping guns unloaded) and the risk of unintentional and self-inflicted firearm injuries.

Design and Setting Case-control study of firearms in events identified by medical examiner and coroner offices from 37 counties in Washington, Oregon, and Missouri, and 5 trauma centers in Seattle, Spokane, and Tacoma, Wash, and Kansas City, Mo.

Cases and Controls Case firearms were identified by involvement in an incident in which a child or adolescent younger than 20 years gained access to a firearm and shot himself/herself intentionally or unintentionally or shot another individual unintentionally. Firearm assaults and homicides were excluded. We used records from hospitals and medical examiners to ascertain these incidents. Using random-digit dial telephone sampling, control firearms were identified by identification of eligible households with at least 1 firearm and children living or visiting in the home. Controls were frequency matched by age group and county.

Main Exposure Measures The key exposures of interest in this study were: (1) whether the subject firearm was stored in a locked location or with an extrinsic lock; (2) whether the firearm was stored unloaded; (3) whether the firearm was stored both unloaded in a locked location; (4) whether the ammunition for the firearm was stored separately; and (5) whether the ammunition was stored in a locked location. Data regarding the storage status of case and control guns were collected by interview with respondents from the households of case and control firearms.

Results We interviewed 106 respondents with case firearms and 480 with control firearms. Of the shootings associated with the case firearms, 82 were suicide attempts (95% fatal) and 24 were unintentional injuries (52% fatal). After adjustment for potentially confounding variables, guns from case households were less likely to be stored unloaded than control guns (odds ratio [OR], 0.30; 95% confidence interval [CI], 0.16-0.56). Similarly, case guns were less likely to be stored locked (OR, 0.27; 95% CI, 0.17-0.45), stored separately from ammunition (OR, 0.45; 95% CI, 0.34-0.93), or to have ammunition that was locked (OR, 0.39; 95% CI, 0.23-0.66) than were control guns. These findings were consistent for both handguns and long guns and were also similar for both suicide attempts and unintentional injuries.

Conclusions The 4 practices of keeping a gun locked, unloaded, storing ammunition locked, and in a separate location are each associated with a protective effect and suggest a feasible strategy to reduce these types of injuries in homes with children and teenagers where guns are stored.

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THE PRESENCE OF A HOUSEHOLD firearm is associated with an increased risk of suicide among adults and adolescents.[1-6] In a study of suicide attempters and completers, investigators found that 75% of the guns were stored in the residence of the victim, friend, or relative.[7] The public health importance of household firearms is a function both of the relative risk of exposure and the prevalence of firearms in the environment of children and adolescents.[8] Schuster et al[9] estimated from the National Health Interview Survey that 35% of homes in the United States with children younger than 18 years reported owning at least 1 firearm, and that 43% of these homes had at least 1 unlocked firearm. Reports from other surveys have derived similar estimates of the fraction of the population at risk from unlocked household firearms.[10]

Unloading and locking all guns and ammunition in the home can potentially reduce access to guns by youth. The policy issue of safe storage of firearms, both in legislative and clinical ap-

For editorial comment see p 740.

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proaches, has received much attention in the medical and public health communities over the past decade.[11,12] Existing evidence supporting this approach to the prevention of firearm injuries among youth is largely derived from ecological studies of the effects of laws requiring parents to securely store firearms.[13,14] Securely storing guns is perhaps a more plausible strategy for unintentional gun injuries among toddlers and young children, but the plausibility of this strategy to reduce youth suicide is less clear.[15] A high level of intent to harm oneself may lead an actively suicidal youth to defeat gunlocks and safes.

To date, only a few studies have indirectly addressed if secure firearm storage is an effective preventive measure for either firearm suicides or unintentional firearm injuries, but few have had sufficient statistical power to detect this association.[1,3] The purpose of this study was to measure the association of household firearm storage practices and the risk of unintentional and self-inflicted firearm injuries associated with child or adolescent access to firearms in the home.

METHODS

Study Design and Case Selection

This study used a case-control design, and the key exposure was firearm storage practices of guns in households with children. The design was not population-based due to the referral patterns of decedents and injured victims to medical examiner offices and trauma centers. The geographic area for both cases and controls included a convenience sample of 37 counties in the states of Washington, Oregon, and Missouri. Nonfatal cases were identified in 5 level I or II trauma centers in the cities of Seattle, Tacoma, and Spokane, Wash, and Kansas City, Mo. Controls were selected from households having both firearms and exposure to children and were identified by random-digit dial telephone surveys.

Case Definition and Identification of Cases

A case firearm was identified by involvement in an incident in which a child or adolescent younger than 20 years gained access to a household firearm and shot himself/herself or another individual. Only suicide attempts and unintentional firearm injuries, both fatal and nonfatal, were included. Assaults and homicides with a firearm were excluded since we believed that gaining access to a valid source of information regarding the storage status of the firearm would be hampered by legal constraints. Shootings must have occurred with a powder firearm such as a handgun, rifle, or shotgun. Shootings with pellet ("BB") or air guns were excluded. Because of the method of control selection, households from which the firearms originated must also have had working telephones. The reference firearm may have originated from either the victim's or shooter's household or from the household of a third party.

Potentially eligible shooting incidents were identified through 3 sources: medical examiners' offices, coroners' offices, and trauma centers. For fatal cases, we queried the offices of medical examiners and coroners from each of the participating counties on a monthly basis to determine if any new cases of firearm deaths to youths younger than 20 years had been recorded. If there was a positive response, these files were reviewed by study staff to determine if the shooting met criteria for inclusion. The medical examiner or coroner made the final determination of intent for each shooting. Study staff reviewed the medical examiner/coroner files, which often included a death certificate, a scene investigation report, and autopsy and police reports. In a number of circumstances, further information from police records was needed to determine if the case met study eligibility criteria, particularly if the source of the gun was unclear. These records were requested by the appropriate law enforcement agency and included in the medical examiner/coroner files for further review. Final determination of eligibility for the study was made after the interview with representatives of the victim's household and/or the household from which the gun originated.

We enrolled cases both prospectively and retrospectively. Potentially eligible "case" firearms were involved in shooting events that resulted in a fatal or nonfatal injury from January 1, 1994, to December 1, 2001. Shootings resulting in nonfatal injuries were only identified prospectively from January 1999 to November 2001. Enrollment for all cases started in January 1999. The earliest shooting incident enrolled in the study occurred in April 1994.

To identify firearms involved in nonfatal injuries, we conducted surveillance at 5 large level I and II trauma centers in 4 cities within the participating counties. Local coordinators reviewed the emergency department logs at these institutions monthly to determine if any potentially eligible cases were seen in the emergency department. All firearm injuries to children and adolescents were reviewed by the study staff and type of intent (unintentional or suicide) was determined based on the medical record.

The gun owner (usually, but not always, the victim's parent) in all potential case events was contacted by letter from the relevant examiner/coroner (for fatal cases) or from one of the investigators (D.C.G. or M.D.D., for nonfatal cases) to introduce the study and to invite participation. A follow-up telephone call by a study team member was conducted to answer questions and schedule an interview.

A total of 525 events involving firearms that potentially met criteria for inclusion as cases were identified from medical examiners, coroners, and hospitals. Of these, 213 were excluded as homicide/assault incidents and 21 were excluded because of uncertain eligibility. Contacts were attempted with a total of 291 potential cases. An additional 23 were found to be ineligible after further information was obtained, leaving 268 who were approached for an interview. Of these, 64 (24%) refused to be interviewed, 80 (30%) could not be located or contacted, and 18 (7%) were found to be ineligible after the in-

terview was completed. A total of 106 of 250 who were potentially eligible (42%) (or 106 of 170 whom we successfully contacted [62%]) were included as cases. Of the 106 cases, 82 (77%) were associated with a suicide attempt, and 24 (23%) were associated with an unintentional firearm injury. Sixty-four cases were from Washington State, 27 were from Missouri or Kansas, and the remainder were from Oregon (n=12), Alaska (n=1), Idaho (n=1), and Montana (n=1). There were no important demographic (victim age and sex, respondent sex, injury intent, and outcome) or circumstantial differences between responders and nonresponders among the cases, except whether the case was prospectively or retrospectively identified. A larger proportion of retrospective cases refused to participate or could not be located.

Control Definition and Identification of Controls

Control firearms were identified from randomly selected households in the same counties from which cases were identified. A control was eligible if there was a firearm stored in or around the house (eg, in the garage, car, or attached storage area) on the date of the matched gun's shooting incident and if there was at least 1 child living or visiting the home at least 2 or more days per year under adult supervision. We attempted to select approximately 4 controls for every case, which were frequency matched by age group (of the shooter) and county of residence. Households in which control firearms were stored were identified by random-digit telephone dialing in counties where case guns were stored. The telephone screening was conducted by a private research firm (Gilmore Research Group, Seattle, Wash) using banks of residential telephone prefixes. At least 10 different attempts were made on different days and times to reach a household before listing it as nonresponsive. When a residence was successfully contacted, the interviewer confirmed that the responder was an adult household member. A brief screening interview with several child safety questions was then conducted to identify potential households with control firearms and child residents or visitors. Eligible respondents were invited to participate in a second interview with one of the study interviewers.

A total of 37 797 telephone numbers were dialed in the eligible counties, and 14 840 contacts were made. A total of 6892 (46%) of screening interviews were refused, and 7320 (49%) completed the screening interview. Of these, 627 (9%) met eligibility criteria for inclusion as controls. Of these, we successfully completed a full interview with 493 respondents (79%). Of these, 480 households with firearms were ultimately determined to be eligible and were included in the final analyses.

Exposure Measurement

Case firearms were defined as the gun used in the fatal or nonfatal shooting incident identified during the study period. Since many homes have more than 1 gun, the control firearms were defined as the household gun most recently fired or acquired. The key exposures of interest in this study were whether the subject firearm was locked and/or unloaded and whether its ammunition was locked and/or stored in a separate location. Additional information was gathered about the type of extrinsic locking device used, if any. The reference date used for exposure recall was the date of the shooting incident for cases or, for controls, January 1 of their respective case's index year.

Respondents were asked questions about each of up to 5 firearms stored in the home, beginning with the case or control gun. For each gun, the type of firearm, purpose, number of years owned, and details of storage (use of various extrinsic locking devices, whether stored loaded) and ammunition (whether stored locked, proximity to firearm) were queried. Up to 3 different extrinsic locking devices were recorded for each firearm, and up to 3 were recorded for the relevant ammunition.

Firearms were categorized with respect to locking status by the reported use (use on the reference date and usual use) of any of the following extrinsic locking devices or practices: trigger lock; lockable box; lockable gun safe, lockable cabinet or gun rack; lockable non–gun-specific safe or box. In addition, guns stored in locked drawers, cabinets, or rooms were categorized as "locked." A similar strategy was used to categorize ammunition storage practices. Respondents were also asked whether guns were stored in the "same location as the ammunition or bullets." Firearms that were stored loaded were classified as being in the same location as ammunition.

Data Collection

All data were collected in a structured interview by 1 of 2 experienced interviewers, either in-person or on the telephone. Both interviewers received additional training in dealing with bereaved family members. In most instances, the respondent was one of the adults residing in the house where the gun was stored. The interview took about 30 minutes. The respondents were shown photographs of various intrinsic and extrinsic safety devices and firearm types to aid recall. If the interview was conducted by telephone, the subjects received a set of photographs by mail prior to the interview. At the completion of the interview, bereaved families were given an opportunity to talk in open-ended fashion about the child and the circumstances surrounding his/her injury or death. If the family desired, written material regarding social and counseling resources for survivors were provided after the interview.

Participants in this study classified their racial and ethnic background during the interview process. Participants used categories developed by the investigators, and these included an option for "mixed race." We collected racial and ethnic data to assess the comparability of the case and control populations in the study. No analyses were performed using race as a predictor variable.

Statistical Analysis

Analyses to calculate odds ratios (ORs) as estimates of the risk ratio of a shooting event associated with gun storage practices and use of specific devices were conducted using multivariable logistic regression, which allowed evaluation and control of other factors that may have affected the relationships of interest. Evaluation of confounding included assessment of several factors for their possible effects on the OR and included (after adjustment for county of residence and ages of children in the home, variables for which controls were frequency matched): respondent sex, age, household annual income level, and education level; type of firearm (handgun vs long gun); sex and age of the firearm owner; number of other guns stored in the home; and whether the reference firearm purpose was recreational or for protection. Only those factors that meaningfully altered the risk ratios (by >10%) were retained in the regression model. Unless otherwise indicated, all risk estimates were adjusted for county, ages of children in the home, and type of reference firearm. Analyses were conducted using SPSS (version 10.5, SPSS Inc, Chicago, Ill) and Egret (version 0.26.6, Cytel Software Corp, Cambridge, Mass) statistical software.

This project was approved by the institutional review board (IRB) of the University of Washington, the University of Missouri-Kansas City Social Sciences IRB, and several hospital IRBs prior to the conduct of this study. All participants gave written informed consent prior to the interviews.

Table 1. Personal and Household Characteristics of Respondents With Case and Control Firearms*

Characteristic	No. (%)	
	Cases (n = 106)	Controls (n = 480)
Respondent sex		
Male	35 (33.0)	144 (30.0)
Female	62 (58.5)	322 (67.1)
Both male and female†	9 (8.5)	14 (2.9)
Race/ethnicity		
White	89 (84.8)	431 (90.4)
Black	6 (5.7)	10 (2.1)
Native American	4 (3.8)	12 (2.5)
Asian/Pacific Islander	2 (1.9)	6 (1.3)
Mixed race	1 (1.0)	7 (1.5)
Other	0 (0)	2 (0.4)
Hispanic	3 (2.8)	9 (1.9)
Homeowner	86 (81.1)	407 (84.8)
Married	74 (69.8)	390 (81.3)
Highest level of education		
High school graduation or less	29 (27.4)	91 (19.1)
Some college or vocational/technical education	54 (50.9)	209 (43.8)
College graduate + graduate education	23 (21.7)	177 (37.1)
Annual household income, $		
<35 000	26 (26.8)	80 (17.4)
35 000-49 999	22 (22.7)	93 (20.2)
50 000-69 999	22 (22.7)	120 (26.0)
≥70 000	27 (27.8)	168 (36.4)
No. of adults living in home		
1	23 (21.7)	55 (11.5)
2	62 (58.5)	353 (73.5)
3	17 (16.0)	60 (12.5)
≥4	4 (3.8)	12 (2.5)
No. of children <20 y living at home		
0	45 (42.5)	134 (27.9)
1	32 (30.2)	109 (22.7)
2	15 (14.2)	152 (31.7)
≥3	14 (13.2)	85 (17.7)
No. of children <20 y living or visiting home ≥2 d per y		
1-4	20 (18.9)	83 (17.3)
5-9	22 (20.8)	116 (24.2)
10-19	27 (25.5)	125 (26.1)
20-39	20 (18.9)	84 (17.5)
40-59	7 (6.6)	29 (6.1)
≥60	10 (9.4)	42 (8.8)
Lives in single-family home	98 (92.5)	438 (91.3)
No. of firearms stored in the home		
1	22 (21.8)	99 (20.9)
2	16 (15.8)	78 (16.5)
3-4	19 (18.8)	113 (23.9)
5-9	23 (22.8)	115 (24.3)
≥10	21 (20.8)	68 (14.4)

*Numbers may not add to totals because of missing values.
†Interviews in which both a male and female respondent participated.

RESULTS

Of the 106 shooting incidents included in the study, there were 82 suicide attempts (95% fatal) and 24 unintentional injuries (50% fatal).

Respondents from households with case and control firearms were generally similar with regard to sex, race, and whether they were homeowners or living in single-family homes (TABLE 1). Respondents from households with case firearms were somewhat less likely to be married, a college graduate, or to have a household income of at least $70 000. They also had fewer children younger than 20 years living in the home; however, the number of children living or visiting at least 2 days per year was similar in both groups.

The median number of firearms stored in homes with case firearms was 4 (interquartile range, 2-8); the median for homes with control firearms was 3 (interquartile range, 2-5, data not shown). Case firearms were more likely to be owned by a male child (21%) than were control firearms (5%) (TABLE 2).

Most of the case (49%) and control (51%) firearms were purchased new or used (25% and 20%, respectively). However, 31% of case guns were primarily for protection compared with 19% of control guns; 26% of case guns were primarily for hunting, compared with 45% of control guns. A greater proportion of case guns (39%) than control guns (27%) had been owned less than 5 years.

Case guns were less likely to be stored unloaded than control guns (OR, 0.30; 95% confidence interval [CI], 0.16-0.56) (TABLE 3). Similarly, case guns were less likely to be stored locked (OR, 0.27; 95% CI, 0.17-0.45), stored separately from ammunition (OR, 0.45; 95% CI, 0.34-0.93), or to have ammunition that was locked (OR, 0.39; 95% CI, 0.23-0.66) than were control guns. Relative to firearms that were unlocked and loaded, those stored locked and unloaded were less likely to be involved in a shooting (OR, 0.16, 95% CI, 0.08-0.33) after adjustment for region, ages of children at home, and type of reference firearm [data not shown]).

The effects of accessibility of the gun and ammunition were also evaluated separately. Having only the ammunition accessible (with the reference firearm locked) was associated with a reduced risk of a case shooting event (OR, 0.34; 95% CI, 0.17-0.66) relative to having both the gun and ammunition unlocked (Table 3). Having both gun and ammunition locked was associated with an OR of 0.22 (95% CI, 0.11-0.44). Having only the gun accessible, but ammunition locked, had an OR of 0.47 (95% CI, 0.19-1.16) for a shooting event.

The practice of locking guns with more than 1 device was not associated with any additional protective effect beyond that observed for use of a single device. The association of different extrinsic locking devices with involvement in shooting events was also assessed. Fewer case guns (32.4%) were stored at the reference date using some sort of locking device compared with control guns (57.7%). Relative to use of no device, the use of a box or safe (alone or in combination with another device) was associated with an OR of 0.26 (95% CI, 0.08-0.84) (Table 3). Use of individual devices relative to nonuse of that specific device was also assessed after adjustment for use of other devices, gun loading status, and type of reference firearm. Although ORs for use of all of the specific devices evaluated were less than 1, only the use of a lockbox/safe was associated with a statistically significant decreased OR for a firearm injury.

Although the use of different devices may vary by type of firearm, our findings related to the 4 main gun storage exposures were generally similar when analyses were stratified by whether the subject gun was a long gun or handgun (TABLE 4). The practices of keeping the reference firearm unloaded, locked, and the ammunition locked were all associated with significantly decreased risks of a shooting event for both types of firearms. With respect to use of different devices, there were no apparent differences between devices. The ORs associated with the use of safes or lockboxes were 0.18 (95% CI, 0.04-0.81) for long guns and 0.17 (95% CI, 0.07-0.45) for handguns (data not shown).

Regardless of whether the injury was unintentional or a suicide attempt (TABLE 5), case guns were less likely to be stored locked or unloaded, and case ammunition was less likely to be locked.

Our findings remained essentially unchanged when stratified by the pur-

Table 2. Characteristics of Case and Control Firearms*

Characteristic	No. (%) Cases (n = 106)	No. (%) Controls (n = 480)
Status of owner		
Male HOH	66 (62.9)	372 (77.7)
Female HOH	6 (5.7)	55 (11.5)
Male child	22 (21.0)	22 (4.6)
Other male relative	7 (6.7)	15 (3.1)
Male + female HOH joint ownership of gun	0	10 (2.1)
Other	4 (3.8)	5 (1.0)
How reference firearm acquired		
Purchased new	47 (49.0)	230 (50.8)
Purchased used	24 (25.0)	89 (19.6)
Gift	12 (12.5)	68 (15.0)
Inherited	8 (8.3)	62 (13.7)
Other	5 (5.2)	4 (0.8)
Primary reason for reference firearm		
Protection	32 (31.4)	90 (19.1)
Sport shooting	20 (19.6)	78 (16.6)
Hunting	26 (25.5)	212 (45.1)
Collecting	2 (2.0)	11 (2.3)
Inherited/gift	13 (12.7)	61 (12.9)
Job	8 (7.8)	11 (2.3)
Other	1 (1.0)	7 (1.5)
No. of years owned reference firearm		
<2	8 (8.2)	46 (10.0)
2-4	30 (30.9)	77 (16.7)
5-9	20 (20.6)	105 (22.7)
10-19	17 (17.5)	109 (23.6)
≥20	22 (22.7)	125 (27.1)

Abbreviation: HOH, head of household.
*Numbers may not add to totals because of missing values.

Table 3. Storage Devices and Practices Used for Case and Control Firearms at Reference Date*

Storage Device/Practice at Reference Date	No. (%) Cases (n = 106)	No. (%) Controls (n = 480)	Odds Ratio (95% Confidence Interval)
Storage practice†			
Gun unloaded	64 (66.0)	429 (90.7)	0.30 (0.16-0.56)
Gun locked	34 (32.4)	274 (57.7)	0.27 (0.17-0.45)
Ammunition locked	24 (24.2)	222 (48.2)	0.39 (0.23-0.66)
Gun, ammunition different locations	41 (41.4)	304 (65.2)	0.45 (0.34-0.93)
Access to gun and ammunition‡			
Both accessible	54 (56.3)	129 (28.0)	1.00
Gun locked/ammunition accessible	18 (18.8)	109 (23.7)	0.34 (0.17-0.66)
Gun accessible/ammunition not accessible	8 (8.3)	61 (13.3)	0.47 (0.19-1.16)
Neither accessible	16 (16.7)	161 (35.0)	0.22 (0.11-0.44)
No. of extrinsic device types used‡			
0	71 (67.6)	201 (42.3)	1.00
1	28 (26.7)	233 (49.1)	0.28 (0.16-0.48)
2-3	6 (5.7)	41 (8.6)	0.32 (0.12-0.84)
Extrinsic device combinations‡			
No device	71 (67.6)	201 (42.3)	1.00
Trigger lock only	9 (8.6)	36 (7.6)	0.56 (0.23-1.36)
On-gun device only	2 (1.9)	7 (1.5)	0.22 (0.04-1.27)
Lockbox/gun safe only	9 (8.6)	101 (21.3)	0.17 (0.08-0.39)
Gun rack only	1 (1.0)	24 (5.1)	0.17 (0.11-1.35)
Gun cabinet only	7 (6.7)	55 (11.6)	0.43 (0.17-1.08)
Lockbox/gun safe + any other	4 (3.6)	27 (5.7)	0.26 (0.08-0.84)
Trigger lock + any other nonbox/safe	1 (1.0)	9 (1.9)	0.33 (0.04-2.96)
Other combination	1 (1.0)	15 (3.2)	0.20 (0.02-1.77)
Any use of specific devices§			
Trigger lock	13 (12.4)	61 (12.8)	0.84 (0.40-1.78)
Lockbox/gun safe	13 (12.4)	127 (26.7)	0.33 (0.16-0.69)
On-gun device	3 (2.9)	18 (3.8)	0.34 (0.09-1.32)
Gun rack	3 (2.9)	31 (6.5)	0.52 (0.14-1.86)
Gun cabinet	6 (7.6)	67 (14.1)	0.89 (0.35-2.25)

*Numbers may not add to totals because of missing values.
†Risks relative to lack of this feature, adjusted for region, ages of children at home, and type of reference firearm.
‡Adjusted for region, ages of children at home, and type of reference firearm.
§Risks associated with use of this device, relative to nonuse of this device, adjusted for region, ages of children at home, type of reference firearm, and any use of other device types. Estimates for trigger lock, box/safe, and cabinet also adjusted for whether gun stored unloaded and ammunition stored locked.

Table 4. Gun Storage Practices Among Case and Control Households at Reference Date by Type of Reference Firearm*

Storage Device Type at Reference Date	Odds Ratio (95% Confidence Interval)† Long Guns	Odds Ratio (95% Confidence Interval)† Handguns
No. of cases/No. of controls	37/336	67/137
Practices†		
Gun unloaded	0.14 (0.04-0.46)	0.38 (0.18-0.77)
Gun locked	0.30 (0.14-0.63)	0.24 (0.12-0.48)
Ammunition locked	0.44 (0.20-0.94)	0.28 (0.13-0.61)
Gun, ammunition different locations	0.52 (0.25-1.07)	0.54 (0.27-1.07)
Access to gun and ammunition†		
Both accessible	1.00	1.00
Gun locked/ammunition accessible	0.39 (0.14-1.07)	0.31 (0.13-0.75)
Gun accessible/ammunition not accessible	0.56 (0.19-1.69)	0.25 (0.05-1.13)
Neither accessible	0.25 (0.09-0.68)	0.17 (0.07-0.43)

*Numbers may not add to totals because of missing values.
†Adjusted for region and ages of children at home.

pose of gun ownership, the sex of the respondent, or when the analyses excluded control guns that had never been fired. For the storage practices of keeping the gun unloaded and locked, the risk estimates were identical regardless of whether the primary purpose of the reference firearm was protection or recreation. The greatest difference observed was for the practice of keeping the gun and ammunition separate when the purpose was recreational (OR, 0.84; 95% CI, 0.42-1.71) vs when the purpose was protection (OR, 0.37; 95% CI, 0.14-0.98 [data not shown]).

The risk estimates for storage practices remained 0.5 or less when analyses were stratified by respondent sex with 1 exception: when the respondent included a male, the OR for keeping ammunition locked was 0.60 (95% CI, 0.27-1.31). When firearms that had never been discharged were excluded, the greatest change occurred for the practice of keeping the gun and ammunition separate (OR, 0.59; 95% CI, 0.36-0.97). Finally, of the households where case guns were stored, 23 respondents reported that a child was the primary owner of the gun. Because parental supervision of gun use may not be as complete in these instances, we also performed subanalyses restricted to only guns owned by adults. This restriction had no appreciable effect on the direction or magnitude of these findings, with the greatest change occurring for the practice of storing the gun and ammunition separately (OR, 0.64; 95% CI, 0.37-1.11). All of these subanalyses, however, were limited by small numbers.

COMMENT

Safe storage practices, including keeping firearms stored unloaded, in a locked place, separate from ammunition, and/or secured with an extrinsic safety device, were shown to be protective for unintentional firearm shootings and suicide attempts among adolescents and children. The 4 specific practices of keeping a gun locked, unloaded, and storing ammunition locked and in a separate location were each as-

sociated with a protective effect and suggest feasible strategies to reduce these types of injuries in homes with children and adolescents where guns are stored. These findings appear to be consistent for both long guns and handguns, as well as for suicides and unintentional firearm injuries.

We are unaware of any other case-control studies that sought primarily to examine the potential protective effects of firearm storage practices for either adults or children. Several investigators, however, have reported on these associations as subanalyses of case-control studies designed to investigate the association between household ownership and the risk of suicide in the home.[1,3] However, those studies were not designed to explore these specific associations. Our findings support several ecological studies of the effect of child (firearm) access prevention laws that showed an association between the law implementation and a reduction in the rate of youth suicides.[13,14]

We are unaware of any controlled analytic studies of firearm storage practices and unintentional firearm injuries among children and adolescents. Wintemute and colleagues[16] reported several case series of unintentional shootings and documented a high rate of accessible and loaded household firearms from these homes.

There are a number of limitations to our study. Our findings may not be generalizable to firearm injuries resulting from homicides and criminal assaults with firearms and may not be generalizable to geographic regions not included in the study. Our study may also not be generalizable to adults or to adolescents living outside of the supervision of their parent. Our narrowly framed case definition only encompassed situations in which a supervising adult lived in the same household where the gun was stored and was aware of the presence of a gun in the household. We were unable to validate the storage status of the reference firearm; however, none of the states involved in the study had laws mandating secure storage and we found respondents rarely refused or were hesitant to disclose the storage status of guns. Furthermore, the findings of storage practices among our control households were similar to those reported in other studies of homes with children.[9,10,17-19]

Table 5. Gun Storage Devices and Practices by Injury Intention

Storage Device/Practice at Reference Date	Odds Ratio (95% Confidence Interval)	
	Unintentional	Suicide
No. of cases/No. of controls	24/480	82/480
Practices*		
Gun unloaded	0.19 (0.07-0.50)	0.39 (0.19-0.78)
Gun locked	0.26 (0.10-0.64)	0.27 (0.16-0.47)
Ammunition locked	0.35 (0.13-0.996)	0.40 (0.22-0.72)
Gun, ammunition different locations	0.60 (0.24-1.48)	0.56 (0.32-0.98)
Access to gun and ammunition*		
Both accessible	1.00	1.00
Gun locked/ammunition accessible	0.31 (0.09-1.00)	0.31 (0.15-0.65)
Gun accessible/ammunition not accessible	0.45 (0.09-2.27)	0.43 (0.16-1.21)
Neither accessible	0.15 (0.04-0.57)	0.22 (0.11-0.47)
Any use of specific devices†		
Trigger lock	1.18 (0.35-3.94)	0.69 (0.29-1.62)
Lockbox/gun safe	0.34 (0.09-1.23)	0.31 (0.14-0.72)
On-gun device	–	0.45 (0.11-1.75)
Gun rack	0.81 (0.09-6.99)	0.45 (0.10-2.05)
Gun cabinet	0.27 (0.03-2.18)	0.61 (0.25-1.47)

*Risks relative to lack of this feature, adjusted for region, ages of children at home, and type of reference firearm.
†Risks associated with use of this device, relative to nonuse of this device, adjusted for region, ages of children at home, type of reference firearm, and use of other device types.

Recall bias is a potential threat to the validity of studies retrospectively collecting exposure data. Although we used photographs to aid identification of locking devices and few respondents appeared to have difficulty recalling this information, it is possible that memory of past storage practices may have been less accurate. When evaluated separately by whether respondents were interviewed within 1 year, or longer than 1 year from the reference date, risk estimates for storage practices were less than or equal to 0.5 with 1 exception: storing the gun separately from ammunition among those interviewed within 1 year of the reference date (OR, 0.78; 95% CI, 0.40-1.53).

We addressed the possibility of differential nonresponse to questions concerning gun storage by conducting subanalyses in which cases with missing information were first categorized as having answered affirmatively to the specific storage practices, and subsequently recategorized as having answered negatively. The largest difference between results given these 2 assumptions was 0.13, and the greatest OR observed was 0.64 (95% CI, 0.39-1.04) for the practice of keeping the gun and ammunition separate under the assumption that all unknown cases had responded affirmatively to this practice; the remainder were all significantly less than 1.

Sampling bias is a potential concern, given that overall response rates for cases and controls were lower than expected. An analysis of case nonresponders (both those who refused to participate and those we could not contact) did not reveal important differences in demographic variables. The only exception was if the case was prospectively or retrospectively identified. Stratification by this variable did not reveal differences. The overall response rate for control households was also below 50%, reflecting the increasing difficulty of conducting telephone surveys for surveillance purposes. Our rate was comparable to a recent report describing the response rates for the Behavioral Risk Factor Survey sponsored by the Cen-

ters for Disease Control and Prevention, in which the median national response rate for states in 2002 was 58% (range, 42%-83%), using reporting standards of the Council of American Survey Research Organizations.[20] The consequence of declining survey response rates has not been associated with increased bias for other public health risk factors.[21] Finally, since this study did not use suicides from all causes as the inclusion criteria for subjects, we cannot assess whether potential attempters who were thwarted from accessing a firearm would complete suicide by an alternate method, if their intent was sufficiently high.

In summary, storing household guns as locked, unloaded, or separate from the ammunition is associated with significant reductions in the risk of unintentional and self-inflicted firearm injuries and deaths among adolescents and children. Programs and policies designed to reduce accessibility of guns to youth, by keeping households guns locked and unloaded, deserve further attention as 1 avenue toward the prevention of firearm injuries in this population.[22,23]

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