SPECIAL ARTICLE

GUN OWNERSHIP AS A RISK FACTOR FOR HOMICIDE IN THE HOME

Arthur L. Kellermann, M.D., M.P.H., Frederick P. Rivara, M.D., M.P.H.,
Norman B. Rushforth, Ph.D., Joyce G. Banton, M.S., Donald T. Reay, M.D.,
Jerry T. Francisco, M.D., Ana B. Locci, Ph.D., Janice Prodzinski, B.A.,
Bela B. Hackman, M.D., and Grant Somes, Ph.D.

Abstract *Background.* It is unknown whether keeping a firearm in the home confers protection against crime or, instead, increases the risk of violent crime in the home. To study risk factors for homicide in the home, we identified homicides occurring in the homes of victims in three metropolitan counties.

Methods. After each homicide, we obtained data from the police or medical examiner and interviewed a proxy for the victim. The proxies' answers were compared with those of control subjects who were matched to the victims according to neighborhood, sex, race, and age range. Crude and adjusted odds ratios were calculated with matched-pairs methods.

Results. During the study period, 1860 homicides occurred in the three counties, 444 of them (23.9 percent) in the home of the victim. After excluding 24 cases for various reasons, we interviewed proxy respondents for 93 percent of the victims. Controls were identified for 99 percent of these, yielding 388 matched pairs. As compared with the controls, the victims more often lived alone or rented their residence. Also, case households more commonly contained an illicit-drug user, a person with prior arrests, or someone who had been hit or hurt in a fight in the home. After controlling for these characteristics, we found that keeping a gun in the home was strongly and independently associated with an increased risk of homicide (adjusted odds ratio, 2.7; 95 percent confidence interval, 1.6 to 4.4). Virtually all of this risk involved homicide by a family member or intimate acquaintance.

Conclusions. The use of illicit drugs and a history of physical fights in the home are important risk factors for homicide in the home. Rather than confer protection, guns kept in the home are associated with an increase in the risk of homicide by a family member or intimate acquaintance. (N Engl J Med 1993;329:1084-91.)

HOMICIDE claims the lives of approximately 24,000 Americans each year, making it the 11th leading cause of death among all age groups, the 2nd leading cause of death among all people 15 to 24 years old, and the leading cause of death among male African Americans 15 to 34 years old.[1] Homicide rates declined in the United States during the early 1980s but rebounded thereafter.[2] One category of homicide that is particularly threatening to our sense of safety is homicide in the home.

Unfortunately, the influence of individual and household characteristics on the risk of homicide in the home is poorly understood. Illicit-drug use, alcoholism, and domestic violence are widely believed to increase the risk of homicide, but the relative importance of these factors is unknown. Frequently cited options to improve home security include the installation of electronic security systems, burglar bars, and reinforced security doors. The effectiveness of these protective measures is unclear, however.

Many people also keep firearms (particularly handguns) in the home for personal protection. One recent survey determined that handgun owners are twice as

likely as owners of long guns to report "protection from crime" as their single most important reason for keeping a gun in the home.[3] It is possible, however, that the risks of keeping a firearm in the home may outweigh the potential benefits.[4]

To clarify these issues, we conducted a population-based case–control study to determine the strength of the association between a variety of potential risk factors and the incidence of homicide in the home.

METHODS

Identification of Cases

Shelby County, Tennessee; King County, Washington; and Cuyahoga County, Ohio, are the most populous counties in their respective states. The population of King County is predominantly white and enjoys a relatively high standard of living. In contrast, 44 percent of the population of Shelby County and 25 percent of the population of Cuyahoga County are African American. Fifteen percent of the households in Shelby County and 11 percent in Cuyahoga County live below the poverty level, as compared with 5 percent in King County.[5-7]

All homicides involving residents of King County or Shelby County that occurred between August 23, 1987, and August 23, 1992, and all homicides involving residents of Cuyahoga County that occurred between January 1, 1990, and August 23, 1992, were reviewed to identify those that took place in the home of the victim. Any death ruled a homicide was included, regardless of the method used. Assault-related injuries that were not immediately fatal were included if death followed within three months. Cases of homicide involving children 12 years of age or younger were excluded at the request of the medical examiners.

Selection of Case Subjects and Recruitment of Case Proxies

A home was defined as any house, apartment, or dwelling occupied by a victim (i.e., a case subject) as that person's principal residence. Homicides occurring in adjacent structures (e.g., a ga-

rage) or the surrounding yard were also included. Murder–suicides and multiple homicides were considered a single event. In the case of a murder–suicide, the homicide victim was included if he or she was older than the suicide victim; in multiple homicides, the oldest victim was included.

Reports made at the scene were collected to ensure that study criteria were met. In King County, the medical examiner's staff conducted all investigations of the homicide scene. In Shelby County and Cuyahoga County, police detectives conducted these investigations. In addition to recording the details of the incident for law-enforcement purposes, investigators obtained the names of persons close to the victim who might provide us with an interview at a later date, thereby serving as proxies for the victim. These lists were supplemented with names obtained from newspaper accounts, obituaries, and calls to funeral homes.

Approximately three weeks after a victim's death, each proxy was sent a signed letter outlining the nature of the project. A $10 incentive was offered, and a follow-up telephone call was made a few days later to arrange a time and place for an interview. At the time of this meeting, informed consent was obtained.

Selection and Recruitment of Controls

After each interview with a case proxy, we sought a control subject matched to the case subject according to sex, race, age range (15 to 24 years, 25 to 40 years, 41 to 60 years, and 61 years or older), and neighborhood of residence. To minimize selection bias, the controls were identified by a previously validated procedure for the random selection of a matching household in the neighborhood.[8-10] After marking off a one-block avoidance zone around the home of the case subject, the interviewer started a neighborhood census at a randomly assigned point along a predetermined route radiating out from the case subject's residence. Households where no one was home were approached twice more, at different times of day and on different days of the week. If contact could not be established after three tries, no further efforts were made. After each neighborhood census was completed, an adult (a person 18 years old or older) in the first household with a member who met the matching criteria was offered a $10 incentive and asked to provide an interview. Whenever possible, attempts were made to interview a proxy for the actual matching control subject. When no interview was granted, the next matching household on the route was approached. If a closer match on the route was found on the second or third visit to the neighborhood, an adult respondent in the closer household was interviewed and any earlier, more distant interviews were discarded. Overall, census data were obtained from 70 percent of the households approached to identify each match. Eighty-four percent of the interviews were obtained from the closest matching household, 13 percent from the second, 3 percent from the third, and <1 percent from the fourth.

Interviews

Case and control interviews were identical in format, order, and content. Each was brief, highly structured, and arranged so that more sensitive questions were not broached until later in the interview. Items drawn from the Short Michigan Alcoholism Screening Test,[11] the Hollingshead–Wilson two-factor index of social position,[12] and a 1978 poll of gun ownership by Decision Making Information[13] were included. Particularly sensitive questions were preceded by "permissive" statements, such as the following: "Many people have quarrels or fights. Has anyone in this household ever been hit or hurt in a fight in the home?"

Statistical Analysis

Data from reports prepared by medical examiners and police were used to describe the study population. Interview data were used for risk assessment, because these were collected in an analogous manner from the case proxies and matching control households. Since members of a household might acquire firearms or remove them from the home in response to a homicide in the neighborhood, answers were adjusted to reflect the state of affairs on the date of the homicide. Mantel–Haenszel chi-square analysis for

matched pairs was used to calculate the crude odds ratio associated with each variable. Multivariate analyses used conditional logistic regression, the appropriate technique for a matched-pairs design.[14]

Potentially confounding variables were identified and controlled for by a two-step process. First, models containing closely related variables (such as those describing the use of alcohol in the home) were constructed to identify the variable or variables in each set that were most predictive of whether the household in question was a case or a control household. Next, a model that incorporated the variables selected in this initial step was constructed to select those that remained significant after we controlled for the effects of the remaining variables in the model. An additional model was constructed to look for interaction effects among the significant variables. Since no interaction terms significantly altered the adjusted odds ratios, the final model included six variables and was based on complete data from 316 matched pairs. After this analysis, an alternative modeling procedure was used to retain potentially confounding variables if they were even marginally significant (P<0.20). Although this approach added two variables, it did not significantly alter the adjusted odds ratios of the six included in our final model.

After completing this initial series of calculations, we examined the relation between homicide in the home and gun ownership, using various strata of the full study sample. To limit bias resulting from potentially faulty reporting, one analysis was limited to pairs with a case interview obtained from a proxy who lived in the home of the victim. To determine whether gun ownership was associated with an increased risk of homicide by firearms as compared with homicide by other means, cases were stratified according to method. To discern whether guns in the home decrease the risk of an intruder-related homicide or increase the risk of being killed by a family member, additional analyses stratified according to circumstance and the relationship between the victim and the offender were also conducted. After these were completed, a comparable series of stratified analyses was performed to assess more clearly the relation between homicide and previous violence in the home.

RESULTS

Study Population

There were 1860 homicides in the three counties during the study period. Four hundred forty-four (23.9 percent) took place in the home of the victim. After we excluded the younger victim in 19 double deaths, 2 homicides that were not reported to project staff, and 3 late changes to a death certificate, 420 cases (94.6 percent) were available for study.

Reports on the Scene

Most of the homicides occurred inside the victim's home (Table 1). Eleven percent occurred outside the home but within the immediate property lines. Two hundred sixty-five victims (63.1 percent) were men; 36.9 percent were women. A majority of the homicides (50.9 percent) occurred in the context of a quarrel or a romantic triangle. An additional 4.5 percent of the victims were killed by a family member or an intimate acquaintance as part of a murder–suicide. Thirty-two homicides (7.6 percent) were related to drug dealing, and 92 homicides (21.9 percent) occurred during the commission of another felony, such as a robbery, rape, or burglary. No motive other than homicide could be established in 56 cases (13.3 percent):

The great majority of the victims (76.7 percent) were killed by a relative or someone known to them. Homicides by a stranger accounted for only 15 cases (3.6 percent). The identity of the offender could not be

established in 73 cases (17.4 percent). The remaining cases involved other offenders or police acting in the line of duty.

Two hundred nine victims (49.8 percent) died from gunshot wounds. A knife or some other sharp instrument was used to kill 111 victims (26.4 percent). The remaining victims were either bludgeoned (11.7 percent), strangled (6.4 percent), or killed by other means (5.7 percent).

Evidence of forced entry was noted in 59 cases (14.0 percent). Eighteen of these involved an unidentified

Table 1. Characteristics of 420 Homicides Committed in the Homes of the Victims.*

CHARACTERISTIC	No. (%) OF VICTIMS
Scene	
Inside residence	373 (88.8)
Within immediate property line	47 (11.2)
Sex of victim	
Female	155 (36.9)
Male	265 (63.1)
Race or ethnic group of victim	
White	140 (33.3)
Black	260 (61.9)
Native American, Eskimo, Aleut	4 (1.0)
Asian or Pacific Islander	7 (1.7)
Other	9 (2.1)
Age group of victim (yr)	
15–24	58 (13.8)
25–40	171 (40.7)
41–60	106 (25.2)
≥61	85 (20.2)
Circumstances	
Altercation or quarrel	185 (44.0)
Romantic triangle	29 (6.9)
Murder–suicide	19 (4.5)
Felony-related	92 (21.9)
Drug dealing	32 (7.6)
Homicide only	56 (13.3)
Other	7 (1.7)
Relationship of offender to victim	
Spouse	70 (16.7)
Intimate acquaintance	58 (13.8)
First-degree relative	40 (9.5)
Other relative	12 (2.9)
Roommate	12 (2.9)
Friend or acquaintance	130 (31.0)
Police officer	4 (1.0)
Stranger	15 (3.6)
Unknown (unidentified suspect)	73 (17.4)
Other	6 (1.4)
Method of homicide	
Handgun	180 (42.9)
Rifle	10 (2.4)
Shotgun	15 (3.6)
Unknown firearm	4 (1.0)
Knife or sharp instrument	111 (26.4)
Blunt instrument	49 (11.7)
Strangulation or suffocation	27 (6.4)
Burns, smoke, scalding	10 (2.4)
Other	14 (3.3)
Victim resisted assailant	
Yes	184 (43.8)
No	140 (33.3)
Not noted	96 (22.9)
Evidence of forced entry	
Yes	59 (14.0)
No	354 (84.3)
Not noted	7 (1.7)
Legally excusable circumstances	
Yes	15 (3.6)
No	405 (96.4)

*Because of rounding, not all percentages total 100.

intruder; six involved strangers. Two involved the police. The rest involved a spouse, family member, or some other person known to the victim.

Attempted resistance was reported in 184 cases (43.8 percent). In 21 of these (5.0 percent) the victim unsuccessfully attempted to use a gun in self-defense. In 56.2 percent of the cases no specific signs of resistance were noted. Fifteen victims (3.6 percent) were killed under legally excusable circumstances. Four were shot by police acting in the line of duty. The rest were killed by another member of the household or a private citizen acting in self-defense.

Comparability of Case Subjects and Controls

Potential proxy respondents were identified for 405 of the 420 case subjects (96.4 percent). Interviews were obtained from 93 percent of those approached in Shelby County, 99 percent in Cuyahoga County, and 98 percent in King County. The households of those who agreed to be interviewed did not differ from the households of those who refused with respect to the age, sex, or race of the victim or the method of homicide (firearm vs. other).

Interviews with a matching control were obtained for 99.7 percent of the case interviews, yielding 388 matched pairs. Three hundred fifty-seven pairs were matched for all three variables, 27 for two variables, and 4 for a single variable (sex). The demographic characteristics of the victims and controls were similar, except that the case subjects were more likely to have rented their homes (70.4 percent vs. 47.3 percent) and to have lived alone (26.8 percent vs. 11.9 percent) (Table 2). Although efforts were made to conduct every interview in person, proxy respondents for the case subjects were much more likely than the controls to request a telephone interview (40.2 percent vs. 12.6 percent). Despite efforts to interview a proxy respondent for each control, only 48.2 percent of the control interviews were obtained in this manner.

Univariate Analysis

Alcohol was more commonly consumed by one or more members of the households of case subjects than by members of the households of controls (Table 3). Alcohol was also more commonly consumed by the case subjects themselves than by their matched controls. Case subjects were reported to have manifested behavioral correlates of alcoholism (such as trouble at work due to drinking) much more often than matched controls. Illicit-drug use (by the case subject or another household member) was also reported more commonly by case households than control households.

Previous episodes of violence were reported more frequently by members of case households. When asked if anyone in the household had ever been hit or hurt in a fight in the home, 31.8 percent of the proxies for the case subjects answered affirmatively, as compared with only 5.7 percent of controls. Physical fights in the home while household members were drinking and fighting severe enough to cause injuries were re-

Table 2. Demographic Characteristics of 388 Pairs of Case Subjects and Controls.*

CHARACTERISTIC	CASE SUBJECTS	CONTROLS
Sex (%)		
Male	63.1	63.1
Female	36.9	36.9
Race or ethnic group (%)		
White	32.9	34.5
Black	62.1	61.6
Native American, Eskimo, Aleut	1.0	0.5
Asian or Pacific Islander	2.8	2.8
Other	1.0	0.5
Age group — yr (%)		
15–24	13.1	13.1
25–40	40.2	40.5
41–60	26.0	26.0
≥61	20.6	20.4
Median years of education of household head	12	12
Median socioeconomic status of household head†	4	4
Type of dwelling (%)		
House	54.6	60.3
Other	45.4	39.7
Rented	70.4	47.3
Owned	29.6	52.7
Median no. of residents/room	0.5	0.6
Lived alone (%)	26.8	11.9
Telephone interview (%)	40.2	12.6
Proxy respondents interviewed	100	48.2

*Because of rounding, not all percentages total 100.

†Socioeconomic status was measured according to the Hollingshead score on a scale of 1 to 5, with 1 as the highest score.[12]

ported much more commonly by case proxies than controls. One or more members of the case households were also more likely to have been arrested or to have been involved in a physical fight outside the home than members of control households.

Similar percentages of case and control households reported using deadbolt locks, window bars, or metal security doors. The case subjects were slightly less likely than the controls to have lived in a home with a burglar alarm, but they were slightly more likely to have controlled security access. Almost identical percentages of case and control households reported owning a dog.

One or more guns were reportedly kept in 45.4 percent of the homes of the case subjects, as compared with 35.8 percent of the homes of the control subjects (crude odds ratio, 1.6; 95 percent confidence interval, 1.2 to 2.2). Shotguns and rifles were kept by similar percentages of households, but the case households were significantly more likely to have a handgun (35.7 percent vs. 23.3 percent; crude odds ratio, 1.9; 95 percent confidence interval, 1.4 to 2.7). Case households were also more likely than control households to contain a gun that was kept loaded or unlocked (Table 3).

Multivariate Analysis

Six variables were retained in our final conditional logistic-regression model: home rented, case subject or control lived alone, any household member ever hit or hurt in a fight in the home, any household member

ever arrested, any household member used illicit drugs, and one or more guns kept in the home (Table 4). Each of these variables was strongly and independently associated with an increased risk of homicide in the home. No home-security measures retained significance in the final model. After matching for four characteristics and controlling for the effects of five more, we found that the presence of one or more firearms in the home was strongly associated with an increased risk of homicide in the home (adjusted odds ratio, 2.7; 95 percent confidence interval, 1.6 to 4.4).

Stratified analyses with our final regression model revealed that the link between guns and homicide in the home was present among women as well as men, blacks as well as whites, and younger as well as older people (Table 5). Restricting the analysis to pairs with data from case proxies who lived in the home of the victim demonstrated an even stronger association than that noted for the group overall. Gun ownership was most strongly associated with homicide at the hands of a family member or intimate acquaintance (adjusted odds ratio, 7.8; 95 percent confidence interval, 2.6 to 23.2). Guns were not significantly linked to an increased risk of homicide by acquaintances, unidentified intruders, or strangers. We found no evidence of a protective benefit from gun ownership in any subgroup, including one restricted to cases of homicide that followed forced entry into the home and another restricted to cases in which resistance was attempted. Not surprisingly, the link between gun ownership and homicide was due entirely to a strong association between gun ownership and homicide by firearms. Homicide by other means was not significantly linked to the presence or absence of a gun in the home.

Living in a household where someone had previously been hit or hurt in a fight in the home was also strongly and independently associated with homicide, even after we controlled for the effects of gun ownership and the other four variables in our final model (adjusted odds ratio, 4.4; 95 percent confidence interval, 2.2 to 8.8) (Table 4). Previous family violence was linked to an increased risk of homicide among men as well as women, blacks as well as whites, and younger as well as older people (Table 6). Virtually all of this increased risk was due to a marked association between prior domestic violence and homicide at the hands of a family member or intimate acquaintance (adjusted odds ratio, 20.4; 95 percent confidence interval, 3.9 to 104.6).

DISCUSSION

Although firearms are often kept in homes for personal protection, this study shows that the practice is counterproductive. Our data indicate that keeping a gun in the home is independently associated with an increase in the risk of homicide in the home. The use of illicit drugs and a history of physical fights in the home are also important risk factors. Efforts to increase home security have largely focused on preventing unwanted entry, but the greatest threat

to the lives of household members appears to come from within.

We restricted our study to homicides that occurred in the home of the victim, because these events can be most plausibly linked to specific individual and household characteristics. If, for example, the ready availability of a gun increases the risk of homicide, this effect should be most noticeable in the immediate environment where the gun is kept. Although our case definition excluded the rare instances in which a nonresident intruder was killed by a homeowner, our methodology was capable of demonstrating significant protective effects of gun ownership as readily as any evidence of increased risk.

Previous studies of risk factors for homicide have employed correlational analysis[15] or retrospective-cohort[16] or time-series[17] designs to link rates of homicide to specific risk factors. However, hazards suggested by ecologic analysis may not hold at the level of individual households or people.[18] In contrast to these approaches, the case–control method studies individual risk factors in relation to a specific outcome of interest. Case–control research is particularly useful when the list of candidate risk factors is large and the rate of adverse outcomes is relatively low. Under these circumstances, it is usually the analytic method of choice.[19]

Although case–control studies offer many advantages over ecologic studies, they are prone to several sources of bias. To minimize selection bias, we included all cases of homicide in the home and rigorously followed an explicit procedure for randomly selecting neighborhood control subjects. High response rates among case proxies (92.6 percent) and matching controls (80.6 percent) minimized nonresponse bias. Case respondents did not differ significantly from nonrespondents with regard to the age, sex, and race of the victim and the type of weapon involved. Although double homicides and murder–suicides were considered single events to avoid overrepresenting their effects, the number of cases excluded for this reason was small.

Other threats to the validity of the study were less easy to control. A respondent's recollection of events can be powerfully affected by a tragedy as extreme as a homicide in the home. To diminish the effect of recall bias, we delayed our contact with the case proxies to allow for an initial period of grief. We also used a simple, forced-choice questionnaire to ascertain information in a comparable manner from case proxies and controls. We tried to obtain data on victims and controls as similarly as possible by interviewing proxy respondents for the controls whenever possible. Although we were able to do so only 48 percent of the time, the responses we obtained from this subgroup were consistent with those obtained from the study population overall.

Potential misreporting of sensitive information was a serious concern, since we had no way to verify each respondent's statements independently. If case proxies or controls selectively withheld sensitive

Table 3. Univariate Analysis of Hypothesized Risk on Protection Factors Derived from Data on 388 Matched Pairs of Case Subjects and Controls.

VARIABLE	CASE SUBJECTS	CONTROLS	CRUDE ODDS RATIO (95% CI)*
	no. (%)†		
Behavioral factors			
Any household member drank alcoholic beverages	277 (73.3)	217 (55.9)	2.4 (1.7–3.3)
Case subject or control drank alcoholic beverages	238 (62.8)	162 (41.9)	2.6 (1.9–3.5)
Drinking caused problems in the household	92 (24.8)	22 (5.7)	7.0 (4.2–11.8)
Any household member had trouble at work because of drinking	32 (9.0)	3 (0.8)	10.7 (4.1–27.5)
Case subject or control had trouble at work because of drinking	20 (5.5)	1 (0.3)	20.0 (4.9–82.4)
Any household member hospitalized because of drinking	41 (11.4)	9 (2.3)	9.8 (4.2–22.5)
Case subject or control hospitalized because of drinking	28 (7.6)	2 (0.5)	14.0 (4.7–41.6)
Any household member used illicit drugs	111 (31.3)	23 (6.0)	9.0 (5.4–15.0)
Case subject or control used illicit drugs	74 (20.3)	16 (4.2)	6.8 (3.8–12.0)
Any physical fights in the home during drinking	92 (25.3)	13 (3.4)	8.9 (5.2–15.3)
Any household member hit or hurt in a fight in the home	117 (31.8)	22 (5.7)	7.9 (5.0–12.7)
Any family member required medical attention because of a fight in the home	62 (17.3)	8 (2.1)	10.2 (5.2–20.0)
Any adult household member involved in a physical fight outside the home	103 (29.9)	70 (18.8)	2.1 (1.4–3.0)
Any household member arrested	193 (52.7)	90 (23.4)	4.2 (3.0–6.0)
Case subject or control arrested	132 (36.0)	60 (15.7)	3.5 (2.4–5.2)
Environmental factors			
Home rented	271 (70.4)	183 (47.6)	5.9 (3.8–9.2)
Public housing	41 (11.1)	38 (9.8)	1.5 (0.7–3.3)
Case subject or control lived alone	103 (26.8)	46 (11.9)	3.4 (2.2–5.1)
Deadbolt locks	243 (68.8)	292 (75.3)	0.8 (0.5–1.0)
Window bars	71 (19.2)	81 (20.9)	0.8 (0.5–1.3)
Metal security door	95 (25.4)	104 (26.8)	0.9 (0.6–1.3)
Burglar alarm	26 (7.1)	43 (11.1)	0.6 (0.4–1.0)‡
Controlled security access to residence	52 (13.9)	38 (9.8)	2.3 (1.2–4.4)
Dog or dogs in home	94 (24.2)	87 (22.4)	1.1 (0.8–1.6)
Gun or guns in home	174 (45.4)	139 (35.8)	1.6 (1.2–2.2)
Handgun	135 (35.7)	90 (23.3)	1.9 (1.4–2.7)
Shotgun	50 (13.6)	65 (16.8)	0.7 (0.5–1.1)
Rifle	45 (12.2)	54 (13.9)	0.8 (0.5–1.3)
Any gun kept unlocked	105 (29.6)	69 (17.8)	2.1 (1.4–3.0)
Any gun kept loaded	93 (26.7)	48 (12.5)	2.7 (1.8–4.0)
Guns kept primarily for self-defense	125 (32.6)	86 (22.2)	1.7 (1.2–2.4)

*Results were calculated with the Mantel–Haenszel chi-square analysis for matched pairs. CI denotes confidence interval.

†Percentages reflect the proportion of subjects who responded yes among all subjects who gave a response.

‡The value is statistically significant; the upper bound of the 95 percent confidence interval is 1.0 because of rounding.

Table 4. Variables Included in the Final Conditional Logistic-Regression Model Derived from Data on 316 Matched Pairs of Case Subjects and Controls.*

VARIABLE	ADJUSTED ODDS RATIO (95% CI)
Home rented	4.4 (2.3–8.2)
Case subject or control lived alone	3.7 (2.1–6.6)
Any household member hit or hurt in a fight in the home	4.4 (2.2–8.8)
Any household member arrested	2.5 (1.6–4.1)
Any household member used illicit drugs	5.7 (2.6–12.6)
Gun or guns kept in the home	2.7 (1.6–4.4)

*Conditional logistic-regression analysis requires that data on all the variables of interest be available for both case subjects and their matched controls. Therefore, 72 pairs with missing data on any of the six variables of interest were excluded from this analysis. CI denotes confidence interval.

information about illicit-drug use, alcoholism, or violence in the home, inaccurate estimates of risk could result. We attempted to minimize this problem by reassuring our respondents of the confidentiality of their responses. We also placed "permissive" statements before each potentially intrusive question to encourage honest replies. Very few respondents refused to answer our questions, although all were assured that they were free to do so.

The rate of domestic violence reported by our control respondents was somewhat less than that noted in a large telephone survey.[20] This may be due to regional or temporal differences in rates of battering, variations in the way we phrased our questions (e.g., screening as compared with an exploratory line of inquiry), or the increased anonymity afforded by telephone interviews as compared with our face-to-face encounters.

Underreporting of gun ownership by control respondents could bias our estimate of risk upward. We do not believe, however, that misreporting of gun ownership was a problem. In two of our three study communities, a pilot study of homes listed as the addresses of owners of registered handguns confirmed that respondents' answers to questions about gun ownership were generally valid.[21] Furthermore, the rate of gun ownership reported by control respondents in each study community was comparable to estimates derived from previous social surveys[22] and Cook's gun-prevalence index.[15]

Four limitations warrant comment. First, our study was restricted to homicides occurring in the home of the victim. The dynamics of homicides occurring in other locations (such as bars, retail establishments, or the street) may be quite different. Second, our research was conducted in three urban counties that lack a substantial percentage of Hispanic citizens. Our results may therefore not be generalizable to more rural communities or to Hispanic households. Third, it is possible that reverse causation accounted for some of the association we observed between gun ownership

and homicide — i.e., in a limited number of cases, people may have acquired a gun in response to a specific threat. If the source of that threat subsequently caused the homicide, the link between guns in the home and homicide may be due at least in part to the failure of these weapons to provide adequate protection from the assailants. Finally, we cannot exclude the possibility that the association we observed is due to a third, unidentified factor. If, for example, people who keep guns in their homes are more psychologically prone to violence than people who do not, this could explain the link between gun ownership and homicide in the home. Although we examined several behavioral markers of violence and aggression and included two in our final logistic-regression model, "psychological confounding" of this sort is difficult to control for. "Psychological autopsies" have been used to control for psychological differences between adolescent victims of suicide and inpatient controls with psychiatric disorders,[23,24] but we did not believe this approach was practical for a study of homicide victims and neighborhood controls. At any rate, a link between gun ownership and any psychological tendency toward violence or victimization would have to be extremely strong to account for an adjusted odds ratio of 2.7.

Given the univariate association we observed between alcohol and violence, it may seem odd that no alcohol-related variables were included in our final multivariate model. Although consumption of alcoholic beverages and the behavioral correlates of alcoholism were strongly associated with homicide, they were also related to other variables included in our final model. Forcing the variable "case subject or control drinks" into our model did not substantially alter

Table 5. Homicide in the Home in Relation to Gun Ownership, According to Subgroup.

SUBGROUP	NO. OF PAIRS	ADJUSTED ODDS RATIO (95% CI)*
Sex		
Female	121	3.6 (1.6–8.1)
Male	195	2.3 (1.1–4.6)
Race		
White	103	2.7 (1.0–6.9)†
Black	196	2.9 (1.5–5.7)
Age (yr)		
15–40	169	3.4 (1.4–8.0)
≥41	147	2.3 (1.2–4.6)
Suspect related to or intimate with victim		
Yes	138	7.8 (2.6–23.2)
No	178	1.8 (1.0–3.4)
Evidence of forced entry		
Yes	46	2.5 (0.7–8.4)
No	219	2.8 (1.5–5.2)
Victim resisted assailant		
Yes	141	3.0 (1.3–6.2)
No	105	3.1 (1.2–8.1)
Method of homicide		
Firearm	159	4.8 (2.2–10.3)
Other	157	1.2 (0.5–2.7)

*All the results were calculated by conditional logistic regression after control for the covariates listed in Table 4. CI denotes confidence interval.

†The value is statistically significant; the lower bound of the 95 percent confidence interval is 1.0 because of rounding.

Table 6. Homicide in the Home in Relation to Prior Domestic Violence, According to Subgroup.

SUBGROUP	NO. OF PAIRS	ADJUSTED ODDS RATIO (95% CI)*
Sex		
Female	121	4.4 (1.6–11.9)
Male	195	4.4 (1.5–12.6)
Race		
White	103	6.9 (1.7–27.6)
Black	196	2.9 (1.2–7.3)
Age (yr)		
15–40	169	5.2 (1.7–16.0)
≥41	147	4.5 (1.7–12.0)
Suspect related to or intimate with victim		
Yes	138	20.4 (3.9–104.6)
No	178	1.9 (0.8–4.7)
Victim resisted assailant		
Yes	141	7.2 (2.1–25.3)
No	105	4.0 (1.0–17.0)
Evidence of forced entry		
Yes	46	1.4 (0.4–4.4)
No	219	8.1 (2.8–23.1)
Method of homicide		
Firearm	159	3.1 (1.0–9.0)
Other	157	5.4 (1.9–15.6)

*All the results were calculated by conditional logistic regression after control for the covariates listed in Table 4. CI denotes confidence interval.

the adjusted odds ratios for the other variables. Furthermore, the adjusted odds ratio for this variable was not significantly greater than 1.

Large amounts of money are spent each year on home-security systems, locks, and other measures intended to improve home security. Unfortunately, our results suggest that these efforts have little effect on the risk of homicide in the home. This finding should come as no surprise, since most homicides in the home involve disputes between family members, intimate acquaintances, friends, or others who have ready access to the home. It is important to realize, however, that these data offer no insight into the effectiveness of home-security measures against other household crimes such as burglary, robbery, or sexual assault. In a 1983 poll, Seattle homeowners feared "having someone break into your home while you are gone" most and "having someone break into your home while you are at home" 4th on a list of 16 crimes.[25] Although homicide is the most serious of crimes, it occurs far less frequently than other types of household crime.[2] Measures that make a home more difficult to enter are probably more effective against these crimes.

Despite the widely held belief that guns are effective for protection, our results suggest that they actually pose a substantial threat to members of the household. People who keep guns in their homes appear to be at greater risk of homicide in the home than people who do not. Most of this risk is due to a substantially greater risk of homicide at the hands of a family member or intimate acquaintance. We did not find evidence of a protective effect of keeping a gun in the home, even in the small subgroup of cases that involved forced entry.

Saltzman and colleagues recently found that assaults by family members or other intimate acquaint-

ances with a gun are far more likely to end in death than those that involve knives or other weapons.[26] A gun kept in the home is far more likely to be involved in the death of a member of the household than it is to be used to kill in self-defense.[4] Cohort and interrupted time-series studies have demonstrated a strong link between the availability of guns and community rates of homicide.[2,15-17] Our study confirms this association at the level of individual households.

Previous case–control research has demonstrated a strong association between the ownership of firearms and suicide in the home.[10,23,24] Also, unintentional shooting deaths can occur when children play with loaded guns they have found at home.[27] In the light of these observations and our present findings, people should be strongly discouraged from keeping guns in their homes.

The observed association between battering and homicide is also important. In contrast to the money spent on firearms and home security, little has been done to improve society's capacity to respond to the problem of domestic violence.[28,29] In the absence of effective intervention, battering tends to increase in frequency and severity over time.[28-30] Our data strongly suggest that the risk of homicide is markedly increased in homes where a person has previously been hit or hurt in a family fight. At the very least, this observation should prompt physicians, social workers, law-enforcement officers, and the courts to work harder to identify and protect victims of battering and other forms of family violence. Early identification and effective intervention may prevent a later homicide.[31,32]

REFERENCES

1. Hammett M, Powell KE, O'Carroll PW, Clanton ST. Homicide surveillance — United States, 1979–1988. MMWR CDC Surveill Summ 1992;41:1-33.
2. Reiss AJ Jr, Roth JA, eds. Understanding and preventing violence: panel on the understanding and control of violent behavior. Washington, D.C.: National Academy Press, 1993:42-97.
3. Weil DS, Hemenway D. Loaded guns in the home: analysis of a national random survey of gun owners. JAMA 1992;267:3033-7.
4. Kellermann AL, Reay DT. Protection or peril? An analysis of firearm-related deaths in the home. N Engl J Med 1986;314:1557-60.
5. Bureau of the Census. 1990 census of population: Tennessee. Washington, D.C.: Government Printing Office, 1992. (Publication nos. CPH-5-44 and CP-1-44.)
6. Idem. 1990 census of population: Washington. Washington, D.C.: Government Printing Office, 1992. (Publication nos. CPH-5-49 and CP-1-49.)
7. Idem. 1990 census of population: Ohio. Washington, D.C.: Government Printing Office, 1992. (Publication nos. CPH-5-37 and CP-1-37.)

8. Yu MC, Mack T, Hanisch R, Peters RL, Henderson BE, Pike MC. Hepatitis, alcohol consumption, cigarette smoking, and hepatocellular carcinoma in Los Angeles. Cancer Res 1983;43:6077-9.
9. Mack TM, Yu MC, Hanisch R, Henderson BE. Pancreas cancer and smoking, beverage consumption, and past medical history. J Natl Cancer Inst 1986;76:49-60.
10. Kellermann AL, Rivara FP, Somes G, et al. Suicide in the home in relation to gun ownership. N Engl J Med 1992;327:467-72.
11. Selzer ML, Vinokur A, van Rooijen L. A self-administered Short Michigan Alcoholism Screening Test (SMAST). J Stud Alcohol 1975;36:117-26.
12. The index of social position: appendix two. In: Hollingshead AB, Redlich FC. Social class and mental illness: a community study. New York: John Wiley, 1958:387-97.
13. Attitudes of the American electorate toward gun control. Santa Ana, Calif.: Decision Making Information, 1978.
14. Hosmer DW, Lemeshow S. Applied logistic regression. New York: John Wiley, 1989.
15. Cook PJ. The effect of gun availability on robbery and robber murder: a cross section study of fifty cities. Policy Stud Rev Annu 1979;3:743-81.
16. Sloan JH, Kellermann AL, Reay DT, et al. Handgun regulations, crime, assaults, and homicide: a tale of two cities. N Engl J Med 1988;319:1256-62.
17. Loftin C, McDowall D, Wiersema B, Cottey TJ. Effects of restrictive licensing of handguns on homicide and suicide in the District of Columbia. N Engl J Med 1991;325:1615-20.
18. Morgenstern H. Uses of ecologic analysis in epidemiologic research. Am J Public Health 1982;72:1336-44.
19. Schlesselman JJ, ed. Case control studies: design, conduct, analysis. New York: Oxford University Press, 1982.
20. Straus MA, Gelles RJ, Steinmetz SK. Behind closed doors: violence in the American family. Garden City, N.Y.: Anchor Press, 1980.

21. Kellermann AL, Rivara FP, Banton J, Reay D, Fligner CL. Validating survey responses to questions about gun ownership among owners of registered handguns. Am J Epidemiol 1990;131:1080-4.
22. Wright JD, Rossi P, Daly K, Weber-Burdin E. Weapons, crime, and violence in America: a literature review and research agenda. Washington, D.C.: Government Printing Office, 1983:212-60, 361-411.
23. Brent DA, Perper JA, Goldstein CE, et al. Risk factors for adolescent suicide: a comparison of adolescent suicide victims with suicidal inpatients. Arch Gen Psychiatry 1988;45:581-8.
24. Brent DA, Perper JA, Allman CJ, Moritz GM, Wartella ME, Zelenak JP. The presence and accessibility of firearms in the homes of adolescent suicides: a case-control study. JAMA 1991;266:2989-95.
25. Warr M, Stafford M. Fear of victimization: a look at the proximate causes. Soc Forces 1983;61:1033-43.
26. Saltzman LE, Mercy JA, O'Carroll PW, Rosenberg ML, Rhodes PH. Weapon involvement and injury outcomes in family and intimate assaults. JAMA 1992;267:3043-7.
27. Wintemute GJ, Teret SP, Kraus JF, Wright MA, Bradfield G. When children shoot children: 88 unintended deaths in California. JAMA 1987;257:3107-9.
28. American Medical Association. Violence against women: relevance for medical practitioners. JAMA 1992;267:3184-9.
29. National Committee for Injury Prevention and Control. Domestic violence. Am J Prev Med 1989;5:Suppl:223-32.
30. Stark E, Flitcraft AH. Spouse abuse. In: Rosenberg ML, Fenley MA, eds. Violence in America: a public health approach. New York: Oxford University Press, 1991:123-57.
31. Mercy JA, Saltzman LE. Fatal violence among spouses in the United States, 1976–1985. Am J Public Health 1989;79:595-9.
32. Kellermann AL, Mercy JA. Men, women, and murder: gender-specific differences in rates of fatal violence and victimization. J Trauma 1992;33:1-5.

IMAGES IN CLINICAL MEDICINE

Images in Clinical Medicine, a regular *Journal* feature, presents a variety of clinically important visual images, emphasizing those a doctor might encounter in an average day at the office, the emergency department, or the hospital. If you have an original unpublished, high-quality color or black-and-white photograph of a typical image that you would like considered for publication, send it with a brief descriptive legend to Kim Eagle, M.D., Massachusetts General Hospital, Cardiac Unit, ACC 4, 15 Parkman St., Boston, MA 02114. Two 5-by-7-inch prints should be sent. If you submit a slide, please send a 5-by-7-inch print along with it. No more than two persons will receive credit for submitting an image.