
Journal of Urban Health: Bulletin of the New York Academy of Medicine Vol. 79, No. 1, March 2002

Unintentional Gun Injuries, Firearm Design, and Prevention: What We Know, What We Need to Know, and What Can Be Done

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ABSTRACT *The public health community has long recognized unintentional gun injuries as a public health issue. In 1998 in the United States, 866 people died from unintentional gunshot wounds, resulting in a crude death rate of 0.32 per 100,000. Unintentional gun deaths have been declining since at least 1920, yet the reasons for this downward trend are not understood. Possible explanations, such as changes in gun ownership and demography, changes in access to guns among population subgroups, safety practices, and artifactual influences are discussed. Intervention strategies for reducing the risk of unintentional gun injury are also discussed.*

KEYWORDS *Firearm design, Unintentional gun injury.*

INTRODUCTION

In the United States, firearms are the most common type of weapon used to commit homicides and suicides. In 1998 in the United States, 30,708 people were killed by gunfire.[1] Unintentional firearm deaths are a relatively small portion of all gun deaths (approximately 3%),[2] and they are amenable to established injury prevention strategies in that they involve modifiable failures in the design of guns.[3] A variety of options currently exist for designing safer guns, and promising new technologies are being developed. Many of these options aim to limit access to unauthorized, high-risk users, such as children, youths, and home burglars. As such, these design modifications may also prove valuable to preventing gun injuries resulting from interpersonal violence and suicides.

This article presents information on three related topics: First, we review the epidemiology of unintentional gun mortality and morbidity, with particular attention to urban populations. We then examine trends in unintentional gun death and discuss hypothesized explanations for those trends. This understanding of the data informs the prevention strategies that constitute the final topic of this article.

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UNINTENTIONAL FIREARM INJURIES: THE STATE OF THE PROBLEM

Mortality

In 1998 in the United States, 866 people died from unintentional gunshot wounds, resulting in a crude death rate of 0.32 per 100,000. Of those who died, 88% were male; 30% were less than 20 years old. Youths aged 15–19 years were the most frequent victims of unintentional gun death (Fig. 1). African Americans and American Indians experienced higher rates of unintentional gun death (0.53 per 100,000 for both groups) than both whites (0.32 per 100,000) and Asian/Pacific Islanders (0.06 per 100,000); however, most (78%) people who died from unintentional gun injuries were white. There was some difference between the rates of unintentional firearm death among Hispanics (0.27) and non-Hispanics (0.35).[2] (Unless otherwise noted, the rates in this paragraph were age adjusted using the US 1940 population as standard.)

Morbidity

As a growing body of literature demonstrates, deaths resulting from unintended gunfire represent a small portion of the total unintentional gun injury burden.[4] In 1998, an estimated 13,698 people in the United States (5.1 per 100,000) were treated in hospital emergency departments for nonfatal, unintentionally inflicted gunshot wounds—approximately 16 surviving victims for every fatality.[4] The same data source reveals that, for every four people treated for nonfatal gun assaults, there was one gun homicide, and for every four gun suicides, one person received treatment for a self-inflicted gunshot wound. Unintentional firearm injuries, which are generally much less lethal than intentionally inflicted gunshot wounds, accounted in 1998 for 21% of all nonfatal firearm injuries treated in hospital emergency rooms.[4]

Level of Urbanization

National mortality data are not currently available in a format that allows for ready examination of deaths by level of urbanization. However, a recent analysis of the 1996–1997 mortality data revealed that adolescents aged 10–19 years living in nonmetropolitan areas experienced higher unintentional gun death rates (1.30 per 100,000) than their "core metropolitan" (0.53 per 100,000) and "other metropolitan" (0.70 per 100,000) counterparts (unpublished data collected for MacKay AP,

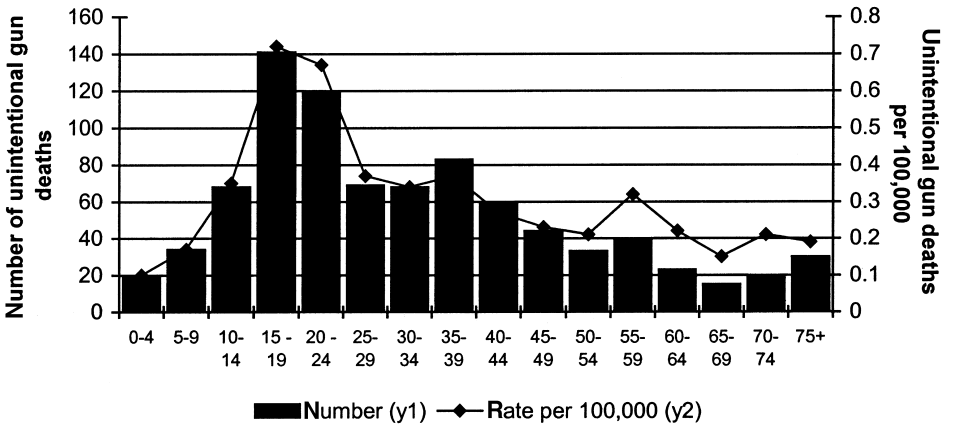

FIGURE 1. Unintentional gun deaths by age, 1998.

Fingerhut LA, Duran CR. *Adolescent Health Chartbook, Health United States*. Hyattsville, MD: National Center for Health Statistics; 2000).

Reports on nonfatal unintentional firearm injuries using data from the National Electronic Injury Surveillance System (NEISS) do not compare rates for urban and nonurban residents. However, state- and local-level studies do provide some information about the frequency of unintentional gun injuries in select urban and rural areas. Unintentional gun injuries constituted 21%–24% of the gunshot wounds among children and adolescents treated in one of two metro areas included in two studies.[5,6] These proportions are similar to findings published by Sing and colleagues,[7] who analyzed the Pennsylvania trauma registry data to determine that unintentional gun injuries accounted for 20% of all firearm injuries in the state's two metro areas. However, within the two central city areas, unintentional firearm injuries made up only 4% of total gun injuries.[7] In contrast, unintentional shootings were responsible for 31%–61% of hospital-treated firearm injuries in studies of select rural areas.[7–9]

Published data from the urban areas studied suggest that nonfatal unintentional gun injury rates vary significantly. The lowest published urban, nonfatal, unintentional gun injury rate is 0.38 per 100,000 and is based on a review of police records in St. Paul, Minnesota, in the late 1980s.[10] This rate stands in sharp contrast to the highest published rate of 40.0 per 100,000 from a population-based study of emergency department data in Philadelphia, Pennsylvania.[11] (The authors of this study note that firearm-related injuries of undetermined intent were coded as unintentional.) While there is great variation among unintentional gun morbidity rates in urban areas, the research literature demonstrates the presence of unintentional injuries on the urban landscape of the United States.

The majority of urban unintentional firearm injuries and deaths involve handguns.[5,10,12–15] Most occur in or near a home[7,10,12,14]; however, one study found that most unintentional gun injuries in Kansas City, Missouri, occurred on the street or in a car while the injured person was concealing a handgun.[5] Detailed information about the circumstances of urban unintentional gun injuries suggests that unintentional gun injuries occur most often while handling or playing with a gun.[12,14] Such findings are consistent with national data.[16]

Unintentional gun injuries are often associated with a rural, hunting lifestyle, and there are a few informative studies that explore the size and circumstances of hunting-related unintentional gun injuries.[17–19] Due to the urban focus of the *Journal*, the issues specific to hunting-related unintentional injuries are not reviewed here.

HISTORICAL TRENDS IN UNINTENTIONAL FIREARM INJURY MORTALITY

The rate of unintentional firearm deaths declined steadily during the 20th century.[20] In 1920, there was a rate of 2.5 per 100,000 for unintentional gun deaths.[21] During the past three decades alone, the rate of unintentional gun deaths declined by 74%, from 1.3 per 100,000 in 1973 to 0.34 per 100,000 in 1998 (Fig. 2).[22]

Aside from recent studies of the effects of Child Access Prevention (CAP) laws that require safe storage of firearms,[23,24] we are unaware of any research that attempts to explain this long-term decline in the unintentional gun death rate. Understanding this trend in injury mortality represents an important challenge for the injury prevention community. Unfortunately, significant data limitations hinder our ability to understand more fully the circumstances surrounding these deaths and the firearms involved.[25] In the absence of empirical findings, we speculate on some plausible explanations for the observed trend.

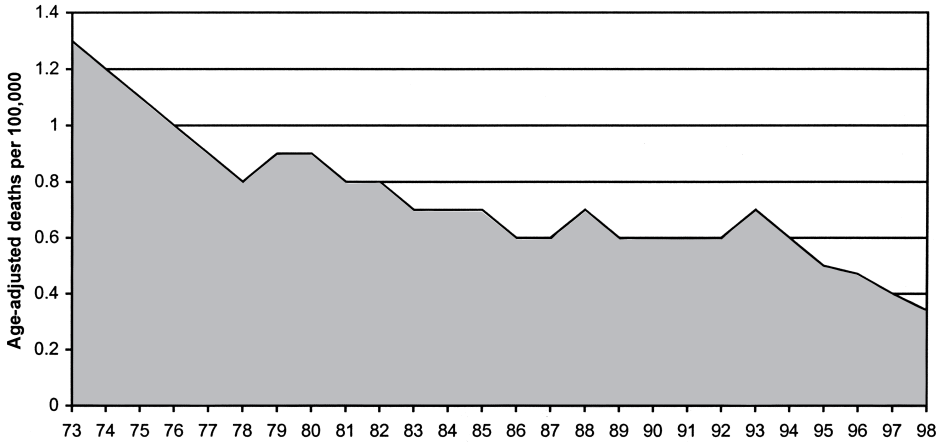

FIGURE 2. Unintentional gun deaths in the United States, 1973–1998.

Gun Ownership and Demography

One likely determinant of the long-term decline in unintentional firearm deaths is the decline in the population's exposure to firearms. While the number of privately owned firearms in the United States increased dramatically in the modern era, the proportion of gun-owning households declined from 47% in 1973 to 32% in 2000—a decline of 32%. Even larger decreases occurred among homes with children and adolescents. In 1973, 52% of households with residents under 18 years old reported having a gun; in 2000, 28% was the comparison figure (unpublished data collected for MacKay AP, Fingerhut LA, Duran CR. *Adolescent Health Chartbook, Health United States*. Hyattsville, MD: National Center for Health Statistics; 2000).[27]

This decline in household prevalence of firearms may be the result of significant demographic changes. Males and rural residents report relatively high rates of gun ownership[26] and experience higher rates of unintentional firearm death than females and urbanites (unpublished data collected for Smith TW. *The General Social Survey*. Chicago, IL: National Opinion Research Center, University of Chicago; 2001). The proportion of the population living in rural areas declined from 1970 to 2000 and was 26% and 20%, respectively.[28,29] In addition, there was a decrease from 88% in 1970 to 71% in 1998 of the percentage of households with an adult male.[29]

Within gun-owning households, there are likely to be differences in the frequency with which gun owners handle their firearms. In contrast to gun owners who keep guns solely for personal protection, sporting gun owners are likely to handle their guns (loading, unloading, cleaning, firing) on a more regular basis. Related to the demographic trends previously discussed is the decline in the proportion of households with a hunter. Smith reports that a 1959 Gallup survey estimated that hunters were present in 37% of households. In contrast, results from the 1996 General Social Survey indicate that 23% of households included a hunter.[30]

Changes in Access to Guns Among Subgroups of the Population

The downward trend in the overall population rate of unintentional gun death masks significant increases and decreases within certain population subgroups.

There is evidence that the well-publicized rise in gun homicides among young black males during the late 1980s and early 1990s was accompanied by a parallel trend in unintentional gun deaths within this group. Black males aged 15–19 years experienced a dramatic increase in unintentional firearm deaths beginning in the mid-1980s that peaked in 1993 and declined significantly throughout the later part of the 1990s (Fig. 3). (Please note the change in scale on the y2 axis in Fig. 3.) Unintentional gun deaths among black males aged 20–24 years also rose and fell with gun homicides during this period (not pictured).

Given that this temporal pattern in youth gun homicide is largely viewed as an urban phenomenon[31] related to changes in access to and carrying of handguns,[32] the unintentional gun death trends among young black males may also reflect additional deaths among urban youths that resulted from changes in exposure to handguns. An association between increased firearm homicide and unintentional firearm deaths in one metropolitan county during the 1960s is noted in the literature.[12]

Safety Practices

Gun storage patterns may have changed over the years, reducing children's access to guns and their risk of unintentional firearm death in households with guns. Unfortunately, surveys of gun ownership have only recently included questions about gun storage practices. In 1989, Florida was the first state in the United States to pass a CAP law. Since the passage of the Florida CAP law, 16 additional states have enacted somewhat similar laws.[23]

An evaluation of the first 12 state CAP laws estimated that unintentional firearm deaths among children aged 0–14 years decreased by 23% as a result of the laws.[24] In a subsequent study of 15 state CAP laws, only Florida showed a beneficial impact associated with the laws. Analyses of data from the other 14 states with CAP laws revealed no measurable law-related change in unintentional gun deaths.[24]

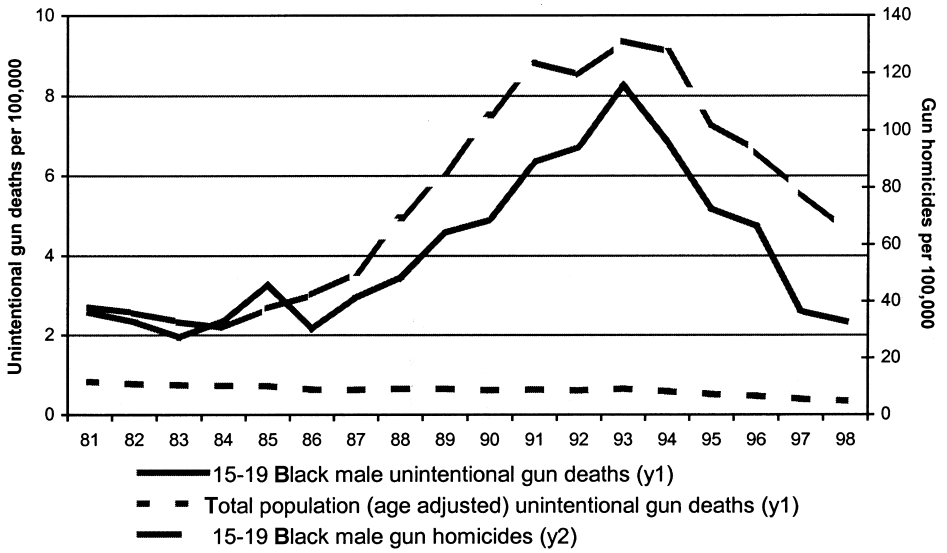

FIGURE 3. Comparison of unintentional gun deaths and gun homocides among young black males, 1981–1998.

While, with the exception of Florida, there was no statistically significant association between unintentional gun deaths among children and CAP laws, it is possible that safer gun storage contributed to the decline in unintentional firearm death rates. The passage of 17 state CAP laws since 1989 may have been a response to gradual changes in normative behavior related to keeping and storing guns in homes with children rather than the cause of a change in norms. If those changing norms are more responsible for the passage of CAP laws than CAP laws are for changing norms further, then pre-post examinations of the effects of CAP laws would fail to detect an impact following the passage of the laws.

Some argue that declining child unintentional firearm deaths may be the result of gun safety education that teaches children how to be safe around guns. However, the only published study to examine the effects of gun safety education on children's behavior around guns found that safety education did not reduce young children's tendencies to handle guns in an unsafe manner when unsupervised.[34]

Artifactual Explanations

Some of the observed decline in unintentional firearm deaths may be an artifact attributable to changes in cause-of-death coding practices for firearm deaths. Historically, coroners and medical examiners at times felt pressured by decedents' families to classify self-inflicted firearm deaths as "unintentional" rather than as "suicide" due to religious taboos, social stigma, and/or concern about loss of life insurance benefits.[35] No definitive reference manual for definitions or determinations of manners of death exists.[36] As a result, coding practices for some firearm deaths are often subjective[36] and therefore are vulnerable to significant variation across time and place. One study demonstrated that the processes coroners used to classify deaths from self-inflicted injuries could explain 24%–37% of county-level variation in suicide rates.[37] In addition, some medical examiners now apply restrictive criteria for classifying a shooting death as unintentional and code every death resulting from one person intentionally firing a shot that kills another person as a homicide even when there is evidence that the shooter thought the gun was not loaded.[38] If this coding practice has increased over time, this could potentially explain a significant portion of the decline in unintentional firearm deaths.

INTERVENTION STRATEGIES FOR REDUCING UNINTENTIONAL GUN DEATH AND INJURY

Product Interventions

In the field of injury prevention, the modification of products often can be more successful in reducing the incidence and severity of injuries than attempted modifications of behaviors. The automobile is a commonly cited example of the safety benefits associated with product modification. Design changes such as airbags, shatterproof windshields, seatbelts, and collapsible steering columns have all been credited with reducing motor vehicle fatalities. The value of product design interventions probably applies to guns, although to date there have not been adequate product modifications or available data[25] to allow for a full test of the hypothesis.

The circumstances surrounding unintentional gun injuries vary, but there are common scenarios that reveal opportunities for product-focused prevention strategies. Many children and adolescents are killed or injured while handling their par-

ents' loaded firearm without parental supervision or permission. Many of these injuries, as well as some unintentional gun injuries involving adults, occur when the person handling the gun believes it is unloaded.

One device that would likely help to reduce unintentional injuries is a loaded chamber indicator. In pistols (now produced in larger numbers than revolvers), the handle or grip of the gun contains the ammunition in a clip or magazine. To fire the handgun, the shooter must first move the slide of the gun to bring a cartridge from the magazine into the chamber of the gun. But, it is not obvious to the person holding the gun whether there is a cartridge in the chamber because the chamber is surrounded by the housing of the gun. This situation can be remedied by equipping all guns with a simple, inexpensive device that indicates whether the gun is loaded.

The need for such a device has been recognized for many years. Patents describe injuries that occurred when the person holding the gun did not know that it was loaded.[39] As noted by several commentators, a handgun that fails to warn of the round in the chamber should be at least as unacceptable as a camera that does not inform its user whether it is loaded with film. Yet, relatively few guns available for sale today are equipped with this potentially lifesaving device.[39]

Another underutilized gun safety device is a magazine disconnect. There are numerous unintentional shootings that occur when someone holding a pistol removes the magazine containing the ammunition and, assuming that the gun is then unloaded, pulls the trigger. Again, when the round that remains in the chamber is still capable of being fired, that is not true. An inexpensive magazine disconnect device can prevent the gun from being fired once a person removes the magazine and so prevent the round in the chamber from causing injury even if a round remains in the chamber. Patents for this device have also existed for about a century. Some handguns utilize this technology, but most do not.[39]

Personalization is the product modification with the potential to reduce the largest number of firearm deaths. By definition, a personalized gun would be inoperable by anyone other than the authorized user of the gun.[40] Children who find a gun in a home and who may not understand that the gun is loaded and lethal would be unable to discharge the weapon. Adolescents who seek out the household gun to show off to friends would, theoretically, be incapable of firing a personalized handgun, potentially eliminating those unintentional gun injuries that occur during play. Gun personalization devices should also prevent many of the approximately 1,300 teenage suicides that occur annually in the United States. In addition, personalized guns stolen from homes would be inoperable by thieves and by anyone who obtains stolen guns from thieves.

Both rudimentary and advanced technologies for personalization of guns are available. A firearm with a built-in combination lock was first available for retail sale in the 1970s.[41] Recently, a major handgun manufacturer announced the introduction of a model with a personal identification number (PIN) device that would prevent unauthorized use of the gun.[42] Another manufacturer offers a gun with an integrated lock (as opposed to a removable trigger lock) that disables the handgun until a removable key is turned.[43] In addition, researchers are examining fingerprint-reading technology as another option for personalizing handguns[44] and personalizing holsters that will retain a handgun until the computer chip verifies the authorizing fingerprints.[45]

Each year, thousands of people are unintentionally killed and injured while handling loaded guns.[4,16] These injuries can likely be reduced by modifying the

product so that either it is apparent that the gun is loaded or it is impossible to fire the gun unintentionally. The technology exists to accomplish this goal; getting the industry to utilize the technology has been the stumbling block.

Legislative and Litigative Interventions

In the absence of voluntary installation of safety devices by gun manufacturers, one can look to legislation and litigation as means to compel gun makers to produce safer guns.[46] Historically, the federal government has not regulated guns and their manufacturers with regard to public safety. Congress expressly forbade the Consumer Product Safety Commission from exercising any jurisdiction over guns and ammunition.[47] The Bureau of Alcohol, Tobacco, and Firearms within the Treasury Department does not regulate the safe design of guns. Thus, although guns are a ubiquitous and dangerous consumer product, guns are unlike other consumer products in that their design is not subject to regulation for the benefit of the public's safety.

Recently, states and cities have taken action to remedy this gap in product safety. In the late 1990s, the Massachusetts attorney general utilized his consumer protection authority to promulgate regulations for the safer design of handguns.[48] Among other aspects, the regulations make guns less operable by children, prohibit the sale of handguns that are prone to accidental discharge, and require new pistols to have either a loaded chamber indicator or a magazine disconnect, thereby reducing the likelihood of unintentional gun injuries. Opponents of this approach challenged these regulations in court, but the court upheld the attorney general's authority.[49] While the court was assessing the legal challenge to the attorney general's authority, the Massachusetts legislature adopted some of the regulations as law. This combination of regulatory and legislative action resulted in some of the strongest consumer product safety oversight of guns in this country.

In 2000, the Maryland legislature passed a law requiring that, beginning in 2003, all new handguns sold in the state be equipped with internal locking devices.[50] These devices, which must be built into the gun itself (unlike detachable trigger locks), would allow the gun owner to secure the weapon from use by unauthorized persons. The primary motivation for this law was to reduce the incidence of unintended injuries to children. Other jurisdictions, including the city of Los Angeles, are now considering variations on the Massachusetts and Maryland laws that would require safer gun design. Congress has introduced similar safe gun design bills, but it is likely that state and local laws will precede any federal action on this issue.

In the absence of rapid progress with consumer product safety legislation, some have turned to litigation as another tool for protecting the public's health. Lawsuits brought by individuals and by governmental bodies (such as cities and counties) on behalf of their citizens against the country's gun makers allege that failure to make guns as safe as feasible should result in liability.[51] Most of these lawsuits have yet to reach the trial stage, but already they are influencing gun design. Smith & Wesson, one of the largest handgun makers in the United States, settled some lawsuits with the stipulation that it will utilize devices such as loaded chamber indicators or magazine disconnect devices in its products, and that it will develop handguns that are childproof and/or personalized.

Interventions to Change Social Norms and Behaviors

As important as product changes are likely to be in further reducing unintentional gun deaths, there will still be a need to alter the behaviors of gun owners so that

guns are less accessible to children. With guns that generally lack safety devices present in about one third of American households, and with many of those guns stored loaded or unsecured,[52] children will remain at risk for unintended injury until the behaviors of gun owners change.

Efforts are now under way to encourage parents to inquire about the presence of guns before sending their children to another's home. The ASK Campaign of PAX[53] seeks to educate parents about the importance of asking other parents whether they have a gun in their home and how that gun is stored so that their children will not be exposed to a potentially fatal risk when visiting playmates. Having parents overcome any reluctance to making or receiving inquiries such as this will entail a change in social norms.

As was the case with child safety seat use in motor vehicles, pediatricians and other health professionals can help to change norms concerning whether to keep guns in homes with children and the safe storage of firearms. While a study of the effects of a single firearm safety counseling session with a pediatrician found no statistically significant change in gun ownership or storage,[54] the impact of such efforts may take years to become evident, and measurable changes in behavior may require other reinforcing messages.

Strategies to change social norms should be viewed as complementary to product-focused interventions and not as a substitute. In addition, researchers should carefully monitor interventions to change social norms to detect and understand any effects. Scientifically based evaluations of such interventions are critical to informed decision making about how best to use scarce resources for gun injury prevention.

CONCLUSION

The hypotheses presented in this article offer a number of possible explanations for the steady decline in unintentional gun deaths in the United States during the previous century. Sound testing of these hypotheses is needed to inform the science of gun injury prevention and to ensure that prevention efforts are effective in reducing gun death and injury. In the meantime, it is important to apply established injury prevention strategies that will allow even the most dangerous of products to be made in a way that minimizes foreseeable injuries.

ACKNOWLEDGEMENT

This article was supported by a grant from the Joyce Foundation of Chicago, Illinois.

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