Unintentional Injuries in Childhood: Analysis and Recommendations

"If some infectious disease came along that affected children [in the proportion that injuries do], there would be a huge public outcry and we would be told to spare no expense to find a cure and to be quick about it."

— Statement by Surgeon General C. Everett Koop before the Subcommittee on Children, Family, Drugs, and Alcoholism, U.S. Senate, February 9, 1989

The twentieth century saw huge successes in health care in the United States. Immunizations, antibiotics, and public health initiatives have combined to lower the infant mortality rate and lengthen life span. Unlocking the secrets of the human genome promises more advances. Despite these advances, we remain stymied by the steady drumbeat of death and disfigurement attributable to childhood injuries. Injuries, both violent and unintentional, are one of the most significant public health issues facing children today, but public outrage is absent. As a result, proven solutions go unused, and thousands of children die each year.

Injuries are the leading cause of death among children between the ages of 1 and 19, and most of these injury deaths can be prevented. In 1996, more than 13,000 children and adolescents in the United States died from unintentional ("accidental") injuries, predominantly resulting from motor vehicle crashes, drownings, and residential fires. This translates, on average, to more than 250 child deaths each week, or approximately 37 child deaths each day. As illustrated in the article by Grossman in this journal issue, although the greatest number of injuries occur among middle- or upper-middle-class white children, poor and minority children experience higher rates of unintentional injuries. This increased risk occurs primarily because they live in environments where heavy neighborhood traffic makes outdoor play areas unsafe, or where safety devices, such as bicycle helmets, car seats, or smoke detectors, are unaffordable or may seem less important than other necessities.
In recent years, scientists have applied the tools of public health and medicine to better understand the incidence of injuries, the risk factors, and the preventive measures needed to successfully reduce the occurrence. This issue of The Future of Children outlines the scope of the childhood unintentional injury problem and reviews the evidence for the effectiveness of injury prevention strategies in physician offices and other clinical settings, in communities, and at state and national levels. This review concludes that the most important task today is not to conduct more research on risk factors for, and the epidemiology of, injury, but rather to conduct rigorous trials of intervention strategies and to translate new and existing research findings into effective prevention programs. This requires adequate funding to design, implement, and evaluate injury prevention programs in addition to training to prepare a cadre of individuals skilled at promoting injury prevention interventions.

Taking these steps and implementing proven interventions, such as child car seats, environmental measures to lessen traffic speed and volume in neighborhoods, bicycle helmets, and smoke detectors, could reduce injury deaths among children by nearly one-third. More than 4,000 childhood injury deaths and nearly 20 times that number of serious nonfatal injuries could have been prevented in 1996 alone. But what approaches should be used to encourage the adoption of these proven interventions? Three distinct approaches to injury prevention—education, environmental/product modification, and enforcement of legislation or regulation—provide pathways for translating knowledge about prevention into effective policy and practice.

Following a brief discussion of the magnitude, trends, and costs associated with childhood injuries and models for injury prevention, the remainder of this article reviews what is known about the effectiveness of these injury prevention approaches. Within each section, the following questions are addressed:

- What are the childhood injury prevention strategies that fit within each approach?
- What is the evidence about the effectiveness of these strategies?
- What are the limitations in knowledge about these strategies?

The promise of the human genome project is enormous, but is not likely to significantly improve child health for some years to come. In contrast, the means are available now to prevent death and disability from injuries to thousands of children in communities across the country.
Why Unintentional Injuries? Why Now?

With many problems afflicting children in the United States today, why should precious resources be invested to prevent injuries, particularly unintentional injuries? The answer to this question lies in the magnitude of the problem, both absolutely and relative to other childhood diseases; in the costs of injury to society; and in the advances in scientific inquiry that make the prevention of many childhood injuries already attainable. Before delving into these discussions, however, a clarification of definitional issues critical to the discussion of injury prevention is necessary.

Injury versus Accident

Until recently, injuries were commonly termed “accidents,” suggesting that these events were unpredictable and unavoidable misfortunes affecting unlucky individuals. This depiction of the problem implicitly suggested that these events could not be prevented. Today, the term “injury” is favored because it more accurately suggests that this is a problem that can be analyzed and averted. Injury is defined as “damage or harm to the body resulting in impairment or destruction of health.”4 Injuries can be fatal or nonfatal, and they can occur unintentionally or as a result of purposeful acts of harm.

Unintentional versus Intentional Injury

The terms “intentional” and “unintentional” denote whether or not an injury was meant to harm the victim.4 For many injuries, intent is obvious. Few would dispute, for example, that a child who broke his or her leg falling from playground equipment was injured unintentionally or that a group of teenagers killed when a peer opened fire in a school yard died from intentional injuries. Sometimes, however, intent is not so easily discerned, such as when a young child comes to the emergency department with a scald burn. Between 7% and 27% of supposedly unintentional injury deaths of young children in reality may be due to abuse or neglect,5 although the abuser’s intent may have been to quiet or discipline the child rather than inflict harm. Because many of the same risk factors—such as a young or unmarried mother,6 poverty, poor parenting, and alcohol and substance abuse7—are associated with higher rates of both intentional and unintentional injury fatalities, it has been argued that prevention research should focus on all injuries, regardless of intent.8–11

Although injury prevention efforts should be focused broadly to encompass all injuries regardless of intent, unintentional injuries to children and adolescents are the sole focus of this journal issue for three reasons: (1) scientific knowledge about the effectiveness of interventions to prevent unintentional injuries is far more advanced than parallel knowledge about the prevention of intentional injuries;8 (2) traditional injury prevention efforts may not be effective in combating the complex psychological and social dynamics manifest in acts of intended harm;12 and (3) most of the strategies to address unintentional injuries to children and adolescents may be more politically feasible than other strategies, such as handgun regulations, that may help prevent injuries caused by intentional acts of violence.

The Injury Problem

Unintentional injuries account for two-thirds of all injury deaths to children and adolescents in the United States.13 Among youths ages 1 to 19, unintentional injuries are responsible for more deaths than homicide, suicide, congenital anomalies, cancer, heart disease, respiratory illness, and HIV combined.14 Although unintentional injuries are the leading cause of death for all children over 1 year, incidence varies by age, with more than half of all unintentional injury deaths occurring to youths ages 15 to 19.

Types of injuries also vary by age group.13 Among children under five years of age, for example, more than half of unintentional injury deaths are due to drowning, suffocation, and motor vehicle occupant injuries. Drowning usually occurs when infants or young children are left unattended, either in the bathtub15,16 or near an open body of water such as a swimming pool.15,17 As children enter the school years and their ability to navigate their immediate environment improves, they fall victim to other types of injury. Among children ages 5 to 14, motor vehicle occupant injuries are the leading cause of injury death, followed by pedestrian injuries. The latter often occur when children dart into the street to retrieve a ball or...
other object.\(^{18}\) Motor vehicle occupant injuries also are the primary cause of injury death among adolescents, accounting for more than half of the injury deaths in this age group. Driver inexperience,\(^{19,20}\) lack of seat belt use,\(^{21}\) alcohol,\(^{21}\) and interactions with other teenagers in the car\(^{22}\) are key contributors to the high rate of fatal crashes among teenage drivers.

Deaths only partially convey the enormous damage caused by childhood injuries. Grossman estimates that approximately 18 hospitalizations and 233 emergency department visits occur for every injury death.\(^{23}\) Among children and youths under 15 years of age, falls are the leading cause of hospitalizations and emergency department visits related to injury. Young children often fall down stairs, fall from beds and sofas, or fall from shopping carts when left unattended, while older children more typically sustain falls associated with sports or other outdoor activities.\(^{24}\) Among adolescents 15 to 19 years of age who have begun to drive, motor vehicle crash injuries are the primary cause of injury hospitalization. These nonfatal injuries often have long-term consequences and can substantially reduce children's quality of life.

**Trends in Injury Deaths**

Unintentional injury deaths have declined by more than 40% during the past two decades\(^{1}\), a trend that demonstrates some of the successes of prevention efforts, better emergency medical services, and acute care that saves the lives of injured children. This trend also is a result of decreased exposure by children to risk associated with, for example, walking.\(^{25}\) This decline translates into a total of nearly 9,700 child and adolescent (ages 0 to 19) deaths averted annually. Decreases in unintentional injury deaths have been observed for every age group and for nearly all causes of injury, though reductions have been most evident among adolescents and for poisoning deaths. This success rate far exceeds the accomplishments for most childhood diseases over a similar time period.

Nevertheless, rates of childhood injury deaths in the United States are still much higher than comparable rates in other developed countries. In 1992, for example, child death rates from unintentional injuries were 8.6 per 100,000 for children ages 0 to 19 living in the United Kingdom\(^{26}\) and 17.5 per 100,000 for the same age group in the United States.\(^{27}\) If the rates for children in the United Kingdom applied in the United States, 6,291 deaths would have been averted that year. The greater success in preventing childhood injuries in other developed countries has been attributed to long-term comprehensive approaches that focus on widespread community change.\(^{28}\) In Great Britain and Scandinavia, for example, child pedestrian injuries have been addressed by modifying neighborhood traffic patterns—slowing traffic with speed bumps or other means and routing heavy traffic around the periphery of residential areas.\(^{29–31}\) As discussed later in this article, if these and other interventions were broadly implemented in the United States, the lives of many more children could be saved each year.

**Cost of Injury**

Based on estimates provided in the article by Miller, Romano, and Spicer in this journal issue, childhood unintentional injuries that occurred during 1996 resulted in $66 billion in present and future work losses due to premature death or long-term disability, $14 billion in lifetime medical spending, and $1 billion in other resource costs. Beyond their financial toll, injuries also affect the quality of life of children and families. Lost quality of life results from pain, loss of motor or cognitive functioning, and premature death attributed to injury, and is valued in nonmonetary terms as quality-adjusted life years (QALY). A QALY uses individual preferences to estimate the tradeoff between a year of perfect health and a year of living with different disabilities. Miller, Romano, and Spicer estimate that for children injured in 1996, quality-of-life losses were equivalent to 2.7 million years of life, a loss comparable to more than 92,000 child deaths.\(^{32}\)

The toll that injuries take on children and their families in terms of death and disability, and the cost of injuries to society, suggest why it is important to invest resources in prevention. The remainder of this article provides a framework for injury prevention efforts and discusses how resources directed at prevention should be invested.

**A Conceptual Model for Injury Prevention**

Modern approaches to injury prevention are grounded in a public health framework that
considers an injury to be the product of the interaction between an individual, the agent or object that causes injury, and the physical and social environment. Injury prevention strategies can target any one or more of these factors.

While public health provides the theoretical foundation for injury prevention efforts, it is the interdisciplinary nature of prevention activities that can be credited with successful reductions in the occurrence of unintentional injury. As discussed throughout this journal issue, successful interdisciplinary efforts draw on the expertise of behavioral science, medicine, urban planning, engineering, law, public policy, and other disciplines, and these efforts focus prevention at the level of the individual, the community, and state and national entities.

The general approaches to injury prevention used today illustrate the interdisciplinary, multifaceted nature of preventive efforts. These approaches include education, environment or product modification, and enforcement of legal or regulatory requirements. Education, such as advice from pediatricians to new parents about the use of infant car seats, is typically used to promote changes in individual behavior to reduce the risk of injury. Education or training of professionals working in the area of injury prevention also is important to teach them what messages and interventions to deliver and how to do this most effectively. Environment or product modification increases safety by altering children’s physical surroundings and changing the design of toys and other consumer products that children use, such as cribs and high chairs. For example, safer physical surroundings may be created by surrounding swimming pools with four-sided fences that have self-latching gates, thereby preventing drowning of young children. Similarly, strangulation may be avoided by narrowing the space between vertical slats in cribs so that an infant’s head cannot be trapped. Enforcement of legislation or regulations can lead to either changes in individual behavior, such as legislation requiring the use of bicycle helmets, or to changes in industry standards, such as child-resistant packaging for medications and toxic household substances.

Interventions also may be active or passive. Active strategies require that a child or caregiver change his or her behavior each time the child begins an activity that has the potential to cause injury. Educating parents to test the temperature of tap water before bathing a child is an active strategy. Passive strategies, such as padded dashboards and shatterproof glass in automobiles, provide automatic protection independent of any individual behavior.

In general, passive environmental strategies, including product modification by manufacturers, are the most effective because they provide automatic protection to large groups of people, including those least likely to undertake “active” measures. However, such strategies often require legal or regulatory enforcement to impose the required changes. When passive strategies are not practical, active strategies that promote behavior change can be effective. Education is critical to these active strategies and plays a complementary role to environmental changes and legal mandates. As a single strategy, education is unlikely to have a noticeable and long-lasting impact on the occurrence of injuries.

The following section examines in more detail evidence on the effectiveness of education, environmental modification, and enforcement approaches to preventing childhood unintentional injuries.

**Educational Strategies**

For decades, most efforts to prevent injuries among children have focused on educational strategies that require individuals to take active steps to change their behavior. These strategies are based on the premise that when parents and children learn how to prevent injuries, they will alter their behavior to do so. Unfortunately, the link between changes in knowledge and attitudes and changes in behavior is weak, and many educational efforts, such as the distribution of brochures or isolated public service announcements, have not worked to prevent injuries.

**Education in Clinical Settings**

The article by DiGuiseppi and Roberts in this journal issue reports that educational interventions focused in a clinical venue, such as a pediatrician’s office or health department clinic, have been effective for
certain injury problems. Efforts that link specific injury problems with specific solutions, particularly those that combine counseling with visual information and free or low-cost safety devices, can increase the adoption of safety behaviors, including car seat use,\textsuperscript{35–40} smoke detector ownership,\textsuperscript{41–44} and safe hot tap water temperature.\textsuperscript{41–43,45} These behaviors are, in turn, linked to reduced occurrences of injury.\textsuperscript{46–48} Unfortunately, the benefits are often relatively small and tend to erode over time.

The limited benefit of education in clinical settings may be due, in part, to the use of ineffective behavioral change techniques. In the past, office-based interventions often relied on negative messages to frighten listeners into behavior change. For example, doctors might have warned children about head injuries or showed them grotesque photographs of bicycle crash injuries to persuade them to wear bicycle helmets. Such tactics may more often result in guilt for failure to change behavior than in successful behavior change.

Newer, more sophisticated techniques, however, rely on positive approaches that are designed to motivate people to want to change behavior. These techniques have been successful in other areas of patient education, including decreasing problem drinking\textsuperscript{49,50} and promoting smoking cessation\textsuperscript{51} and could be equally applicable to injury prevention. Foremost among these techniques is motivational interviewing, which fosters openness to behavior change and can be applied to a variety of risk behaviors.\textsuperscript{52} In motivational interviewing, the clinician focuses on increasing the client's intrinsic motivation so that change arises from within rather than being imposed from without. Motivational interviewing is an attractive approach for childhood injury prevention, since it is conducted in brief interventions and can be repeated at each encounter a pediatrician has with a child, adolescent, or parent. Unfortunately, most schools of medicine and nursing do not currently teach motivational interviewing, leaving even newly trained health care providers without the skills to employ this technique.

Although few rigorous studies have evaluated the use of more positive approaches to address injury problems, it is likely that these approaches can be effective at increasing the adoption of safety practices such as bicycle helmets, car seats, and smoke detectors in homes. Nonetheless, we suggest that as brief and more positive interventions are implemented by physicians and nurses in clinical settings, the effects on safety behaviors and subsequent injuries should be evaluated.

These educational interventions can succeed, however, only if physicians and other health care providers take the time with their patients to deliver them. Unfortunately, few incentives are in place in today's health care system to encourage physicians and other health care providers to invest time in educating parents and their children about safety practices to prevent injury. Patients switch insurance plans and health care providers so frequently that many health care plans are unwilling to invest in prevention when the rewards of decreased health care costs may occur in the long term only. In addition, physician reimbursement for services delivered to poor children covered by Medicaid—those at greatest risk of unintentional injury\textsuperscript{53}—is less than half that provided through private fees,\textsuperscript{54} creating further disincentives for injury prevention in clinical settings. Quality indicators for health plans, therefore, should include injury prevention counseling to encourage higher reimbursements for this service.

**RECOMMENDATION**

- Pediatricians and other health care providers should incorporate education about safety practices into routine health visits, using positive behavioral counseling. To encourage the provision of these services, private insurers and state Medicaid programs should reimburse adequately for them, and the National Committee for Quality Assurance (NCQA) should make injury prevention counseling a measured indicator of the quality of health plans.

Although few rigorous studies have evaluated the use of more positive approaches to address injury problems, it is likely that educational interventions in clinical settings are not a panacea, and clinical counseling in isolation is unlikely to lead to major reductions in childhood injury. Nonetheless,
these strategies will continue to play a critical role in future efforts to prevent childhood injury. Prevention is a cornerstone of pediatric practice, and counseling to prevent injury has been recommended by the American Academy of Pediatrics (AAP), in 1996, and the U.S. Preventive Services Task Force, also in 1996. Moreover, pediatricians and other health care professionals are well respected and credible sources of information, so they may be some of the best and most persuasive experts to carry the injury prevention message.

**Education in Broader Community Settings**

Educational approaches also have been used in community-based interventions to prevent childhood injuries. As the article by Klassen and colleagues in this journal issue reports, these multifaceted interventions can occur in clinics, schools, neighborhoods, and cities, and they have resulted in the increased use of bicycle helmets and car seats among children. The most successful of these community-based injury prevention programs are guided by an accepted health behavior framework in which interventions are designed to impact a series of factors that all link to the desired behavior change. In one approach of this type, efforts to change behavior begin with changing attitudes and increasing knowledge. These are then followed by making safety products available at low cost and are reinforced through repeated messages on the same topic in multiple settings, such as in the physician’s office, on television, at church, and in school. Generally, health behavior frameworks all use an array of techniques to promote and reinforce long-term change.

Despite the effectiveness of some community-based injury prevention efforts, such programs are uncommon in communities across the United States and should be more widely implemented. The Seattle Bike Helmet campaign is an excellent example of a comprehensive community-based program that could be implemented in other communities. By increasing parents’ awareness of the effectiveness of bicycle helmets, changing peer norms to make helmets “cool,” and subsidizing helmet costs, this campaign increased bicycle helmet use among children and adolescents from about 2% to 60% in 10 years. The multifaceted approach adopted by model programs such as this should be tested and used to target other important child injury problems.

**RECOMMENDATION**

- Effective community-based injury prevention programs grounded in a health behavior framework, such as those shown to increase bicycle helmet and car seat use, should be implemented in every community. New programs based on these models also should be developed and evaluated in communities to target other prevalent child and adolescent injury problems, such as pedestrian injury, drowning, and motor vehicle injury associated with the misuse of car seats and seat belts for small children.

Although some community-based interventions to reduce childhood injuries have been successful, many other efforts have not been rigorously evaluated or have not been effective at increasing safety practices or reducing injuries. This is largely because many programs have not been developmentally appropriate or have been implemented poorly or only for short periods of time. Nevertheless, based on some very successful programs and their theoretical approaches, such strategies should work if they are well implemented. Advances in research methodology and statistical analytic techniques make it more feasible to conduct trials of community-wide interventions today and such trials can help determine the most effective community-based educational strategies to prevent injuries to children.

**Environment and Product Modification**

Many of the most notable advances in public health have occurred through changes in the environment rather than because of antibiotics or changes in individual behavior. The provision of clean water, for example, has been far more effective in preventing diarrheal diseases than has instructing mothers on formula preparation or using antibiotics to treat diarrhea. Similarly, changes in the environment and the modification of consumer products...
also have dramatically decreased the incidence of childhood injuries. For example, the use of child-resistant caps for medications and household poisons and limits on the number of pills in a single vial for many over-the-counter medications saved the lives of about 460 children under the age of five between 1974 and 1992.84

Severe burns to children from residential fires and scalding tap water also have been reduced using environmental strategies. Clothing burns in children are always severe and often fatal because the burns tend to be large and deep. As a countermeasure, the Flammable Fabrics Act of 1971 required children’s sleepwear to be flame-retardant. As a result of this change in industry standard, clothing burns involving sleepwear have decreased substantially,85 although efforts to relax the standard may result in their resurgence.66 Another common source of burns has been hot tap water, but since a pediatrician in Seattle, Washington, pointed out the dangers of water heaters commonly set at 130°F to 150°F, many states and heater manufacturers now require that water heaters be preset at a lower, safe temperature.48,87 Since water heaters typically require replacement after approximately 10 years,88 tap water scald burns are rapidly becoming a rare event.

There is tremendous potential to further reduce childhood injuries by more widely implementing strategies to make children’s physical environments safer. “Traffic calming” efforts to reduce or slow the speed of traffic in neighborhoods, for example, have successfully reduced the risk of pedestrian injuries in Europe and in some American cities,89-92 but they still are not widespread. These strategies—which may include lowering speed limits in residential areas, installing speed bumps, and routing heavy traffic away from neighborhoods—make communities more aesthetically pleasing as well as more pedestrian friendly. Studies have shown that traffic calming slows vehicle speed and reduces pedestrian injuries, in some cases by close to 70%.90

Fences with self-latching gates that enclose swimming pools on all sides are required by law in countries such as New Zealand and in many areas of Australia. These fences have been estimated to prevent roughly 40% to 70% of swimming pool drownings and near-drownings among young children.93,94 In the United States, most communities that require residential pools to be fenced allow one side of the fence to be the outside wall of a home, thereby leaving young children who enter the pool area from the home exposed to tremendous danger.95 The mandatory use of four-sided swimming pool fences could save the lives of hundreds of children each year, particularly in California, Florida, and Arizona, states where drowning is the leading cause of injury death among children under five years of age.95

**RECOMMENDATION**

- Passive strategies that make children’s environments safer, such as traffic calming measures and fences that enclose swimming pools on all sides, should be implemented in all communities and mandated by law.

What is the common thread that ties these successful interventions together? These strategies are all “passive”: Once implemented, they do not require repeated behavior change from the individual or family. In contrast, educational interventions require repeated, “active” behavior changes. Passive strategies are particularly effective for children and high-risk groups for whom active interventions may be unrealistic. Of course, many successful interventions use a combination of educational messages and environmental or product changes to employ both active and passive approaches to injury prevention. For example, bicycle helmets (a passive intervention) protect the head from injury regardless of the cycling behavior of the rider, yet active educational strategies are needed to promote helmet use. Such combined approaches can be remarkably successful.60,96

Although passive environmental strategies are among the most effective at reducing childhood injuries, some of these strategies may be designed so that their benefit is unrealized or even harmful. For example, air bags were installed in cars because few drivers were actively buckling their safety belts. Although air bags have decreased
adult driver deaths substantially, they have resulted in the deaths of least 84 child passengers in the past decade. This problem is due in part to a lack of adequate testing of air bags. The government has subsequently developed new child-sized dummies, required that manufacturers test air bags with these dummies, supported the development of "smart" air bags that will sense the size of the front-seat occupants, and introduced a widespread educational effort to alert parents to the risks of children riding in the front seat. Examples such as this indicate the importance of evaluating new passive approaches, even when they seem to make clear sense.

These and other environmental modifications and product design changes will be most successful if they are shaped through partnerships of health and safety professionals with manufacturers and urban planners, among others. Such partnerships help to sell a product and thus can be good business for corporations. The safety features of cars, for example, are one of the most important factors affecting decisions about new car purchases.

Enforcement of Legislation and Regulation

Legislation and regulation are among the most powerful tools to improve children's health. For example, one of the most effective methods to ensure that children are fully immunized is to require certification of immunization for school entry. Most of the environmental modification and product design changes described above to reduce injury also require legislation or regulation. As outlined in the article by Schieber, Gilchrist, and Sleet, these legal actions have substantially reduced the risk of injury to children. Laws have been passed in all 50 states requiring that infants and young children be adequately restrained in car seats, for example. As a result, car seat use for infants and toddlers in the United States is about 85% and 60% respectively, and an estimated 71% of motor vehicle occupant deaths to young children can be prevented with the appropriate use of these devices. Similarly, increasing the legal age for purchasing alcohol to 21 has resulted in substantial reductions in motor vehicle crashes and related fatalities among adolescents.

Many existing laws, however, are not fully enforced or have loopholes that limit their effectiveness, and some effective laws have not been uniformly adopted in every state. For example, laws governing car seat use for children are a patchwork of different regulations across the 50 states, and most states do not require appropriate protection for children between the ages of approximately four and eight, who are too large for a child safety seat and too small to use a regular shoulder-lap belt safely. These children should be restrained in a belt-positioning booster seat, but few states require this. Bicycle helmet laws also vary from state to state. Even though research has shown that bicycle helmets are approximately 85% effective at reducing head injuries, 35 states still do not have statewide laws mandating helmet use for young bicyclists. The incidence of injuries to children could be further reduced by more widespread implementation and enforcement of laws that are known to protect children from harm.

The regulation of available technology could substantially reduce the risk of other childhood injuries as well. Injuries caused by fires, for example, could be reduced by requiring that all cigarettes be fire safe and by requiring the installation of hardwired or lithium battery-operated smoke alarms in all homes. These interventions may be particularly important for children under five years of age, who are especially at risk of dying in house fires. Cigarettes are the leading cause of fire-related deaths in the United States, and fire-safe cigarettes would be much less likely to start a fire if dropped compared with regular cigarettes. Federal studies have determined that it is technically feasible to produce such a cigarette, though they are not routinely manufactured.

Functioning smoke detectors lower the risk of death in house fires by more than 60% among both children and adults. Unfortunately, nearly all residential smoke detectors in the United States are battery operated, and although educational programs have increased smoke detector use in the short term, many of these smoke detectors are not operational three to four years later because batteries are removed or wear out. This problem could be reduced if the smoke detectors commonly used today were replaced with those that use lithium batteries.
which last about 10 years compared with about 1 year for standard battery-operated alarms, or if all new homes were required to have smoke detectors hardwired into the home electrical system, thus eliminating the need for batteries altogether.

RECOMMENDATION

- Uniform legislation should be enacted and enforced in every state to mandate the following safety practices: age-appropriate car seat or booster seat use for children; bicycle helmet use; and residential smoke detectors that are hardwired or use lithium batteries. The National Center for Injury Prevention and Control (NCIPC) should catalog model legislation and state activities for these and other injury prevention strategies.

Legislation to prevent injuries is often embroiled in arguments about restriction of personal freedom, on the one hand, and a contribution to societal health and welfare, on the other. Too often the issues are politicized, and the compromise becomes lost in the heat created by the debate. Injury control and child advocates do not always acknowledge the restriction on personal freedom that is inherent in legal actions, while individuals who oppose these actions often ignore society’s role in paying for the public’s health and its duty to protect vulnerable members of society, especially children. Motorcycle helmet laws, for example, have been vociferously opposed by motorcyclists as a restriction of their freedom, but there is a societal cost to that freedom. Studies have shown that two-thirds of the costs of care for motorcyclists injured in crashes are paid through public dollars. The same scenario is true of many other injury problems, and the public may have a special obligation to intervene when the target population is children and adolescents who cannot vote or speak for themselves in public debate.

Science can inform this debate about whether or not to enact injury prevention legislation by estimating the effectiveness of interventions to prevent injuries, the costs of injuries, who pays these costs, and how these costs would be reduced by the proposed legislation. To maximize the benefit to society at large, legislation should be passed only if the benefits of the legislation outweigh the costs to society. Cost-effectiveness studies, those that weigh the costs of a particular injury prevention intervention against the benefits of averting injuries, have been conducted for a limited number of injury prevention strategies. Seven injury prevention strategies—bicycle helmets, car seats, smoke detectors, childproof cigarette lighters, poison control centers, zero tolerance of alcohol for drivers under age 21, and provisional licensing for teenage drivers—were identified in the article by Miller, Romano, and Spicer as at least as cost effective as other child health measures. Unfortunately, knowledge of the cost effectiveness of many other injury prevention strategies is not available.

RECOMMENDATION

- Information on the cost effectiveness of strategies to reduce injuries to children must be collected to better inform public debate on the merits of these interventions.

Public policy change is key to reducing childhood injuries, and individuals working in this area need to better understand the mechanisms for influencing the policy process. While information on the cost of injuries and the effectiveness and cost-effectiveness of prevention efforts is necessary to inform the policy debate, political science about public policy also is critically important. For example, what scientific information is needed to best inform public policies to prevent injuries? How is this information best disseminated to policymakers? How can the energy of parent groups and families of victims best be harnessed to bring about policy change? Understanding the interplay of factual information, political power, societal values, and competing priorities is central to the enactment of effective public policies. Since legislation and regulation are among the most effective tools to prevent injury, the injury control community and child advocates must be better educated in the political science of public policy change.
The Future of Injury Prevention

Although current knowledge about what does and does not work to prevent childhood injuries is extensive, the implementation of effective interventions has not been widespread. Deficiencies in four areas have stymied injury prevention efforts of the past and continue to be a problem today: (1) the absence of detailed and reliable data on nonfatal injuries; (2) the lack of training to prepare a multidisciplinary group of professionals to enter the field of injury prevention; (3) inadequate funding; and (4) the lack of coordinated prevention efforts. Expansion of efforts in these areas will be critical to further reducing the occurrence of childhood injuries in the coming years.

Injury Data

Reliable data on childhood injuries is a necessary building block for prevention efforts. Although numerous state and national data sources monitor injuries and their consequences, most include data only on serious injuries that result in death. A major impediment to injury prevention efforts today is the lack of detailed information in many data systems on the external cause of nonfatal injuries (for example, fall from stairs; suffocation by plastic bag). For all injury-related deaths that occur in the United States, coding of the external cause is recorded on the death certificate, but such coding for nonfatal injuries that lead to a hospitalization or emergency department visit is not universal.

The use of external cause codes (known as E codes) for nonfatal injuries is critical to assess a community's injury problem and to target interventions appropriately. For example, a community could track the frequency of head injuries among children; reported E codes in hospital records might reveal that most of these head injuries were due to bicycle crashes. With this information, the community could then develop targeted prevention efforts to increase the use of bicycle helmets.

Despite the benefits of E-coded data and the low cost of their collection, Grossman reports in this journal issue that only 23 states have mandated that hospitals report external cause of injury codes, and only 11 states have the capacity to provide such coding in statewide emergency department data systems. The reporting of E codes traditionally has been considered optional, largely because these codes are not required for hospital reimbursement and for a long time the uniform billing form for hospitals did not have space for external cause codes. The latter has changed, however, and now the uniform billing form used by hospitals has a dedicated space for reporting E codes. Mandatory inclusion of external cause of injury codes in hospital discharge data would add tremendously to the knowledge needed to make homes and communities safer for children.

**RECOMMENDATION**

- The mandatory recording of external cause of injury codes should be required for hospital discharge data systems in all 50 states. Medical providers and hospital information system staff should be trained to use these codes for all admitted cases of nonfatal injury.

Training

Training clinical and research professionals to work in the field of injury prevention is critical to the testing and widespread implementation of interventions that reduce childhood injuries. Training in injury prevention is needed for professionals such as nurses, physicians, and emergency medical technicians who work in hospitals, clinics, and public health agencies. Training also is needed for professionals such as engineers, lawyers, urban planners, legislators, and government officials, who also are among the key players in the most effective injury prevention strategies. All too often, though, even health care professionals lack injury prevention training. A 1996 survey of a sample of medical students in the United States, for example, found that few were knowledgeable about the magnitude and causes of unintentional injuries, the principles of injury prevention, or the effectiveness of intervention programs.

Smith, Dellapenna, and Berger discuss an effective model to train professionals. This model, developed and implemented by the Indian Health Service, combines
classroom instruction with community service and has prepared an effective cadre of injury control professionals to work in American Indian communities across the United States. These professionals have implemented a number of innovative programs, such as the use of "floatcoats" (personal flotation devices that double as overcoats) to prevent drownings in Alaska. These programs have dramatically reduced rates of injury in many American Indian and Alaska Native communities. This same model of training could be widely disseminated to train injury control professionals working in other settings.

RECOMMENDATION

- State and local governments, hospitals, and nongovernment organizations that implement injury prevention programs should require employees to obtain training in the principles of injury control. Funding of these programs should be tied to this training requirement.

Training should also extend to the research community. Limited funding has resulted in few training programs or career development awards for new injury researchers, and new funding similar to the National Institutes of Health funding for physicians engaged in clinical and patient-oriented research should be launched. In addition, schools of public health and other university-based research programs and fellowships should include courses on injury control research methods in their curricula.

RECOMMENDATION

- National training programs and career development awards for injury control investigators should be developed and funded by federal agencies.

Funding for Injury Research

During the past few decades, advances in injury prevention have been slowed by limited funding for research and practice. Until recently, advances in the injury field have been greatest for motor vehicle injuries because of the investments by the National Highway Traffic Safety Administration (NHTSA), the Federal Highway Administration, and automotive manufacturers, while funding for research and prevention has lagged far behind in other areas of injury. As reported in the article by Miller, Romano, and Spicer, although the medical costs of treatment for injury, vascular disease, and cancer are similar, research funding for these diseases (ranging from about $900 million to $1.6 billion) is probably two to four times that spent on injuries (about $370 million).

How much the federal government spends on injury prevention and treatment research, especially research on unintentional injuries among children and adolescents, can only be estimated, because spending spans many agencies, including the National Institute of Child Health and Human Development, the NCIPC within the Centers for Disease Control and Prevention, the NHTSA, the Consumer Product Safety Commission, and others. Agency budgets do not separate out spending for child and adolescent injuries, and spending on violence prevention and unintentional injury prevention often is combined. More precise estimates of current federal funding are necessary to prioritize intervention strategies and to make judgments about the allocation of funds to this problem.

RECOMMENDATION

- A comprehensive analysis of federal spending on child and adolescent injury prevention and control should be undertaken. Based on this analysis, on knowledge of the magnitude and costs of injuries, and on the effectiveness of prevention efforts, federal funding for injury research should be set at a level commensurate with the problem.

The Need for Coordinated Prevention Efforts

Preventing childhood injuries requires concerted efforts by a number of federal and state government agencies in collaboration with the nonprofit sector. Although many
public and private agencies work in injury prevention, too often advocates focus on single injury issues (for example, motor vehicle injuries, drownings, or fire-related injuries), vying for limited funds and the attention of busy policymakers. This fragmentation of efforts signals the need for a national agenda in injury control. Since many of the solutions to prevent injuries transcend age groups, an agenda for injury control should include all ages, yet pay special attention to areas of injury where children are uniquely at risk. Such efforts must be spearheaded by a lead agency, and the NCIPC is the logical choice. The NCIPC has the broadest perspective of any federal agency involved in injury control because its scope is not confined to a particular type of injury or focus on intent. It also was anointed as the lead agency in the National Research Council's 1985 report Injury in America, and it has served in that role over the past decade.9

The coordinated federal agencies should take some specific actions. First, a designated federal agency should serve as a clearinghouse for all federally funded injury research data and should make that data available to the public in a timely fashion. Second, information should be gathered and disseminated on what does and does not work to prevent injuries. This information should be based on scientifically rigorous studies, routinely updated, and made available to communities that are developing injury prevention strategies. Finally, a system of injury surveillance should be established that captures all injuries treated in hospital inpatient units and emergency departments.

RECOMMENDATION

A national agenda for preventing unintentional injuries should be developed and implemented through coordination of federal efforts across a variety of agencies under the lead of the NCIPC.

The implementation of coordinated efforts to prevent unintentional injuries is not only the responsibility of federal agencies, nongovernment organizations, and private foundations also are key participants in these endeavors. As the primary caretakers of state and local vital and health statistics, for example, state and local health departments monitor the occurrence of serious injuries in the community, identify the neighborhoods and locales with the highest injury rates, and implement interventions targeted at these high-risk areas as well as other economically disadvantaged areas.

Nongovernmental organizations play a critical role in raising the visibility of injury problems, garnering public support for prevention efforts, and prompting policymakers to act. A well-known nonprofit organization, Mothers Against Drunk Driving (MADD), for example, has been credited with changing social norms about driving while under the influence of alcohol and has influenced the adoption of stricter legislation concerning alcohol-impaired driving.11 It is often the advocacy work of nonprofit organizations that heightens public outrage about specific injury issues, setting the stage for the widespread implementation of effective prevention efforts.

Private foundations can leverage the work being done across public and private sectors by supporting efforts to gather information on what works to prevent injuries and making this available to organizations and agencies, by supporting the implementation of effective programs in communities across the country, and by funding training programs to ensure that efforts in the field are focused on effective prevention strategies.

Conclusions

Unintentional injury deaths to children have declined about 40% in the past two decades, but it is inappropriate to be complacent. Unintentional injuries remains the leading cause of death among children and adolescents ages 1 to 19, and injuries claim more children's lives each year than any disease. Despite a plethora of injury prevention strategies demonstrated to be effective, the implementation of these strategies has lagged far behind knowledge of their impact, holding back overall declines in injury-related disability and death among children and youths in the United States.

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About 37 children die each day from preventable injuries in this, the wealthiest nation in the world and the nation with the most sophisticated medical interventions. Preventing these deaths will depend on the dedication of individuals to implement what is known to work, the determination of communities to create environments where children can grow up safely, and the public and private dollars to support injury prevention research and dissemination of effective interventions.

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3. These figures were estimated using the number of child injury deaths and nonfatal injuries that required hospitalization in 1996, taken from the article by Grossman in this journal issue.


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32. These are only estimates and depend on the weighting system used.


74. The most rigorous evaluation design to test the effectiveness of an intervention is the randomized controlled trial. In such trials, random assignment is used to allocate subjects to either receive an intervention or to be in a control group that does not receive the intervention. This study design is the best way to test the effects of an intervention compared with other interventions or with the status quo (see the article by DiGuiseppi and Roberts in this journal issue). Random assignment becomes more complicated when communities rather than individuals are the target of a program.


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