Injury Control: New Challenges

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Objectives

After completing this article, readers should be able to:

1. Describe the activities that encompass injury control.
2. Describe restraint systems that should be used for children younger than age 9 years riding in a motor vehicle.
3. List the risk factors that substantially increase the likelihood of teen motor vehicle crashes.
4. Describe the factors that have been shown to reduce the risks associated with teen driving.
5. Compare standard ionization smoke detectors and photoelectric detectors.
6. List the preferred pool safety design features.

Introduction

Although there have been major reductions in the number of children and adolescents dying from injuries in the United States over the last 2 decades, trauma remains the most important cause of serious morbidity and mortality in the pediatric age group beyond infancy. Pediatricians play a central role in reducing the toll from injuries, a role that stretches beyond their office and into the community. In this article, we review the current magnitude of the problem and discuss prevention for some of the most important injuries to children and adolescents.

Definitions

The injury control model is based on the concept that the overall burden of trauma can be reduced through the primary prevention of injuries, optimal acute care of the injured patient, and rehabilitation to regain as much preinjury functioning as possible. The focus of this review is primary prevention, but the other components of injury control are within the purview of pediatricians and should not be ignored (Fig. 1).

The injury control community has shifted away from use of the term "accident" to use of the term "injury." More than just a semantic difference, this represents a shift in thinking from the idea that "accidents" are, for the most part, random, unpredictable, and nonpreventable events to the approach that "injuries" are preventable and to some degree predictable. It also focuses attention on the damage to the individual and the methods of controlling this damage through primary prevention, acute care, and rehabilitation. In addition, this conceptual shift allows similar approaches to control of intentional injuries (ie, assaults and self-inflicted injuries) and unintentional injuries (ie, "accidents") that employ the same tools.

Epidemiology

In 1998, more than 18,000 children and adolescents in the United States died from injuries (Table 1). Two thirds of these injuries were unintentional, with motor vehicle injuries accounting for the single greatest cause of death. The cause of injury death varies with age. Drowning and fire and burn injuries exact the greatest toll in younger children; intentional injuries are primarily a problem in older adolescents. Motor vehicle occupant injuries are a leading cause of trauma death at all ages, but the number of deaths increases

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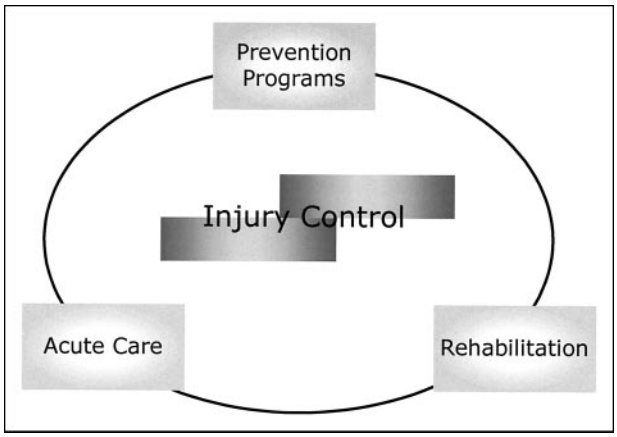

Figure 1. The expanded spectrum of injury control.

dramatically in the later teen years as adolescents become drivers and ride with other teen drivers.

Although death is the most serious outcome from trauma, there are an estimated 18 injury hospitalizations and 200 injury-related emergency department (ED) visits for each child injury death. Among children younger than 21 years of age, there are more than 500,000 hospital admissions for injuries annually. More than 10 million injured children and adolescents are treated each year in hospital EDs. Falls represent the most common injury leading to ED care for children younger than age 15 years; being struck by or against something and motor vehicle injuries are the most common sources of ED trauma visits for teens ages 15 to 19 years.

Motor Vehicle Occupant Safety

Prevention of motor vehicle injuries must be approached from a developmental perspective because the reasons for injury occurrence and the prevention strategies vary substantially across the pediatric age spectrum. Many of the strategies are well known and are not reviewed here; rather, we concentrate on newer problems and strategies.

Occupant Protection for 4- to 8-year-old Children

Pediatricians have been at the forefront of occupant protection for infants and toddlers. All 50 states have laws mandating the use of child restraint devices for infants traveling in motor vehicles; many state laws also cover toddlers and children up to 3 years of age. When children graduate from child car seats, they commonly are placed in adult seat belts or travel unrestrained. Only about one fifth of 4- and 5-year-old children are reported always to be restrained in a child-specific device. Some children place the shoulder belt of adult restraint systems behind them because it comes high across the neck or even the face. Others slouch forward in the seat to allow the knees to bend over the edge of the seat, which causes

Table 1. Injury Deaths by Age and Mechanism (United States, 1998)

Injury Mechanism	Younger Than 1 y	0 to 4 y	5 to 9 y	10 to 14 y	15 to 19 y	Total
Unintentional						
Motor Vehicle	155	467	604	839	4,823	6,888
Pedestrian	7	292	230	197	351	1,077
Drowning	63	496	243	201	439	1,442
Fire/Burn	43	264	197	104	87	695
Bicycle	0	9	70	124	66	269
Firearm	0	19	34	68	141	262
Fall	20	45	26	29	90	210
Suffocation	376	152	61	72	52	713
Other	56	160	67	58	519	860
Total	720	1,904	1,532	1,692	6,568	12,416
Intentional						
Suicide	0	0	7	317	1,737	2,061
Firearm Suicide	(0)	(0)	(1)	(153)	(1,087)	(1,241)
Homicide	322	399	170	290	2,311	3,492
Firearm	(0)	(63)	(60)	(194)	(1,898)	(2,215)
Total	322	399	177	607	4,048	5,553
Intent Unknown						
Total	75	43	15	51	139	323
TOTAL	1,117	2,346	1,724	2,350	10,755	18,292

Source: Centers for Disease Control and Prevention, WISQARS, 2001.

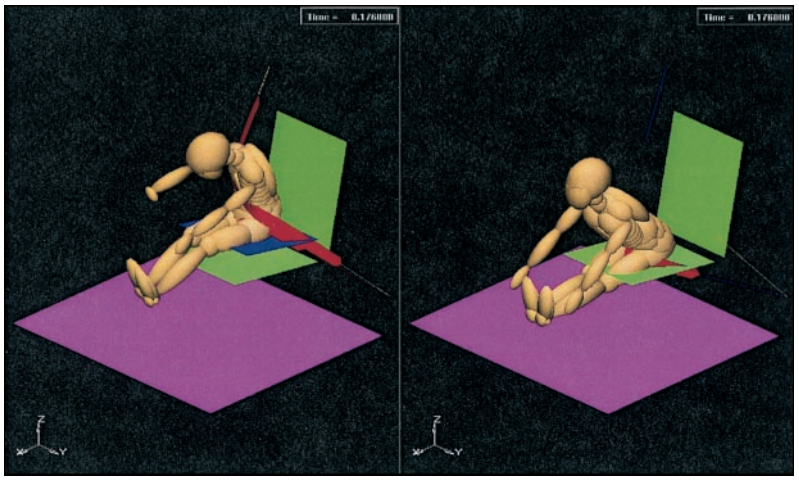

Figure 2. Comparison of booster seated (left) and nonshoulder belted, nonbooster-seated (right) 6-year-old child dummy model in a 35 mph motor vehicle crash. The lap belt causes a predictable pattern of injuries. Booster seat use with lap-shoulder restraints is recommended for children up to 8 years of age.

the lap belt to ride up on the abdomen instead of being anchored on the bony pelvis.

There are clear hazards to young children using adult restraint systems. Seat belt-related injuries commonly consist of perforation and deserosalization injuries of the intestine and flexion-distraction injuries of the lumbar spine, with potential for cord damage (Fig. 2). In addition, there is an increased risk of head injuries from striking the interior parts of the car. These injuries are due to the lap belt riding up onto the abdomen instead of being anchored on the pelvis and lack of adequate restraint of the torso in a crash.

Seat belt-related injuries can be prevented through the use of booster seats, which are perhaps better labeled "belt-positioning devices." These relatively inexpensive seats raise the child up to allow proper use of the shoulder harness and provide an "artificial pelvis" to serve as the anchor points for the lap belt. Available data indicate that they can reduce the risk of injury substantially among children in the 4- to 8-year age group. Educational programs can increase use because most parents are unaware of the proper age for graduation of children to adult restraint systems (Table 2). A successful program in Seattle doubled booster seat use within 1 year. The impact of educational programs can be enhanced through legislation mandating use. Washington was the first state to pass such legislation, and other states, including Arkansas and California, have followed. Up-to-date information on choosing the correct car seats for children is available from the American Academy of Pediatrics (Table 3).

Rear Seat Position

Ample data indicate that the rear seat is safer than the front seat for both children and adults. One study of children younger than age 15 years found that the risk of serious or fatal injury in a crash was 27% lower for children in the rear seat compared with those sitting in the front seat. In addition, studies conducted by the National Highway Traffic Safety Administration and others indicate that airbags increase the risk of death for children younger than age 13 years who are seated in the front seat. Front airbags appear to offer little protection to children in a crash, but present a risk of serious or fatal injury from airbag deployment. The safest place for children clearly is in the rear seat, properly restrained for their age and size. Educational and legislative interventions to increase the number of children traveling in the rear have been successful.

Teen Drivers

Motor vehicle crashes are the most common cause of injury death among teens in the United States. About 50% of teens who die in motor vehicle crashes are passengers; about 60% of those who die are riding with a teen driver. The risk of motor vehicle crashes is highest among teen drivers and higher among males than females. A 16-year-old teen driver is seven times more likely to crash per mile driven than is a 25- to 29-year-old driver. Research over the last decade has revealed a number of important risk factors for this increased likelihood to crash as well as some effective countermeasures.

The number of passengers traveling with teen drivers appears to have a clear influence on the risk of crash. The risk of death among 17-year-old drivers is 50% greater driving with one passenger compared with driving alone; this risk is 2.6-fold higher with two passengers and threefold higher with three or more passengers. The risk is increased further if the passengers are younger than 30 years of age. Dangerous driving behaviors, such as speeding, swerving, running a red light, and drinking while driving, are more common if peers are in the car.

Nighttime crashes account for more than one third of teen motor vehicle fatalities. Teens are five- to tenfold more likely to be in a fatal crash driving at night compared with driving during the day. The difficulty of

Table 2. Proper Child Safety Seat Use

	Infants	Toddlers	Young Children
Weight	Birth to 1 y and up to 20 to 22 lb (9 to 9.9 kg)	Older than 1 y and 20 to 40 lb (9 to 18 kg)	40 to 80 lb (18 to 36 kg)
Type of Seat	Infant only or rear-facing convertible	Convertible/Forward-facing	Belt-positioning booster seat
Seat Position	Rear-facing only	Forward-facing	Forward-facing
Always Make Sure:	Children to 1 y and at least 20 lb (9 kg) in rear-facing seats Harness straps at or below shoulder level	Harness straps at or above shoulders Most seats require top slot for forward-facing	Belt-positioning booster seats must be used with both lap and shoulder belts. Make sure the lap belt fits low and tight across the lap/upper thigh area and the shoulder belt fits snug, crossing the chest and shoulder to avoid abdominal injuries
Warning	All children ≤12 y should ride in the back seat		

Source: National Highway Traffic Safety Administration.

driving at night combined with the inexperience of teen drivers is a deadly combination.

Driving after drinking increases the risk of a crash at all ages, but especially for teens. Studies show that the threshold for impairment of driving skills is far below the 0.1 g/dL blood alcohol level commonly defined as intoxication. Recognizing this, all states have now adopted a "zero tolerance" policy for alcohol use among teen drivers. As a result of these and other policies, alcohol-involved fatal crashes among teens have decreased by 61% over the last 2 decades to a low of 21% of fatal crashes in 1998.

Table 3. Useful Web Sites

AAP guide to choosing correct car seats
http://www.aap.org/family/carseatguide.htm
AAP Family Shopping Guide for Car Seats
http://www.aap.org/family/famshop.htm
Bicycle Helmet Safety Institute
http://www.bhsi.org/
CDC National Center for Injury Prevention and Control
http://www.cdc.gov/ncipc/nicpchm.htm
Consumer Products Safety Commission
http://www.cpsc.gov/
National SAFE KIDS Campaign—unintentional injury prevention
http://www.safekids.org/
SafeUSA—public/private injury control alliance
http://www.cdc.gov/safeusa/default.htm
Systematic review of child injury prevention
http://depts.washington.edu/hiprc/childinjury/

One strategy for addressing the risks of teen driving is a program of graduated driver licensing (GDL). GDL is based on the premise that driving is a skill that must be practiced, and the time of practice for new drivers should occur under the safest possible conditions. In the past 4 years, 34 states and the District of Columbia have implemented GDL systems. To be effective, at least three stages in GDL are necessary: a beginner stage that has maximum restrictions to ensure safe learning, an intermediate stage that has restrictions on passengers and nighttime driving, and a final stage of unrestricted licensing. A teen moves through the stages only when skills have been demonstrated without citations or crashes and there has been sufficient time for practice. Recent studies from North Carolina and Michigan indicate that fatal crashes among 16-year-old drivers declined by 57% and 25%, respectively, following the institution of GDL. Not surprisingly, GDL laws are widely supported by most parents.

High school driver education is a rite of passage for most teens in the United States. A recent evaluation of high school driver education, however, found no good evidence that teens who complete these courses have fewer crashes or violations than those who do not. No differences were found in the short or long term. Additionally, there may be a hidden risk in these programs if state law allows teens who take driver education to be fully licensed at an earlier age. If more young drivers are on the road without a demonstrable increase in driver safety, the net effect may be an increase in motor vehicle deaths.

Head Injuries During Recreational Sports

Approximately 250,000 people are hospitalized each year in the United States for traumatic brain injury (TBI), and about 50,000 die. TBI accounts for 70% to 80% of trauma deaths in children, with a particularly high risk among adolescent males. Many survivors have lifelong disability. The most common cause of TBI among children is motor vehicle crashes. Strategies to reduce motor vehicle occupant injury, described previously, are crucial in the prevention of childhood TBI. However, recreational injuries are another important cause of TBI that are amenable to injury control efforts.

Bicycles are ubiquitous in childhood; unfortunately, many children do not practice proper riding habits or wear bicycle helmets. Consequently, 30% of bicycle deaths occur in the 5- to 14-year-old age group. Although 90% of these deaths involve collision with a motor vehicle, most nonfatal head injuries are the result of a simple fall. More than 100,000 child cyclists suffer nonfatal head or facial injuries each year, with 20% sustaining a traumatic brain injury.

Studies of helmet effectiveness reveal that helmets decrease the risk of bicycle-related TBI by 70% to 88%. They also appear to decrease the risk of injury to the mid- and upper face by 65%. Helmets are effective at all ages and appear to provide benefit whether the crash is a result of a fall or collision with a motor vehicle. The Consumer Product Safety Commission (CPSC) now sets standards for all helmets sold in the United States. Safe helmets can be purchased for less than $20. Community-based programs have been effective in increasing the use of helmets by children. These programs are most effective when they involve multiple venues for the message, when physicians are involved, and when legislation requires children to be helmeted.

Parents play a key role in bicycle safety for children. Studies by various groups indicate that most children wear helmets if their parents or accompanying adults are helmeted; fewer than one third of children are helmeted if the accompanying adult fails to wear a helmet. Inculcating the need for wearing a helmet from the first time children ride is the best way to ensure helmet use throughout childhood. Just as young children should not cross streets by themselves, parents need to choose safe areas for young children to bicycle that are away from traffic. Most severe bicycle injuries occur in bicycle-motor vehicle collisions. Parents should limit riding by adolescents who refuse to wear helmets.

Head injuries are common in other sports, including skiing, snowboarding, horseback riding, and skateboarding. Although case-control studies have not examined helmet effectiveness for these sports, as they have for bicycling, the overwhelming evidence from studies of bicycle helmets and the availability of helmets for these other sports at a reasonable price strongly argue for their use.

Burns

Nearly all fire and burn-related deaths to children and adolescents in the United States are due to residential fires. Most of these deaths occur at the scene and are due to smoke inhalation. Those at greatest risk are children younger than age 5 years and the elderly. Counseling to prevent residential fires might include advice to quit smoking (or to keep matches and smoking materials securely stored) and to maintain and use space heaters or other electrical devices properly. Unfortunately, the benefit of such counseling is unproven.

Smoke detectors are designed as early warning devices to alert residents that a fire has started so they can vacate the premises and call the fire department. Smoke detectors appear to decrease the risk of fatality in a house fire by 60% to 70%. The prevalence of smoke detectors in the United States varies from 79% in Hawaii to 99% in Maryland. Homes that are most likely to require protection (older dwellings in deprived areas) are least likely to have working smoke detectors.

One barrier to smoke detector effectiveness is homeowners taking out the batteries because of frequent false alarms. Among smoke detectors that failed to alarm in a house fire, 59% had been disconnected from their power source, most commonly because of nuisance alarms. One approach to reducing false alarms is to employ photoelectric rather than ionization smoke detectors. Photoelectric detectors have a far lower false alarm rate and are more sensitive to smoldering fires. Unfortunately, most smoke detectors in current use are ionization detectors, in part because they are about half the price.

Counseling in physician offices may increase smoke detector ownership and use. Pediatricians can remind families to replace detector batteries every 6 months and to consider obtaining photoelectric detectors if nuisance alarms are a problem. A more practical approach may be to ask public health nurses or other home health visitors to provide information about proper smoke detector installation and use, along with access to low-cost safety equipment. Families also can be encouraged to develop and practice a fire escape plan for their home.

Scald injuries are the most common burns in children younger than 4 years of age. Children may be burned when they pull hot liquids onto themselves from a stove, counter, or table. Children have thinner skin than adults

and suffer deeper injuries when exposed to the same amount of thermal energy. In addition, a given volume of hot liquid burns a larger proportion of a child's skin surface than an adult's. Families can be reminded to use the rear burner on the stovetop, to turn pot handles away from exploring hands, and to keep hot liquids at least 10 in from the table's edge.

Tap water scalds can occur while bathing or washing with inadequate supervision. Although parents always should supervise bathing, simple adjustments to the water heater may be a more effective countermeasure to prevent these scald injuries. Tap water at 160°F (40.7°C) can produce a full-thickness scald burn in less than 1 second. At 120°F (48.4°C), many minutes of exposure are required to produce the same degree of injury. Although many new water heaters are factory-set to maintain a lower water temperature, most families are not served by new water heaters. Parents should be encouraged to test the temperature of their hot water, adjust the water heater as required, and retest the temperature. A water temperature of 120°F (48.4°C) reduces the risk of unintentional tap water scalds, saves energy and energy expenses, and will not appreciably affect the cleaning function of most appliances. Pediatricians may need to advocate for this change on behalf of families living in apartment dwellings.

Drowning

Submersion injuries to children are unique because of their high case fatality rate. The outcome for most children who drown is determined by their status on arrival at the ED; aggressive medical and intensive care unit care appear to have relatively little impact on outcomes. Thus, reduction in morbidity and mortality must come from primary prevention.

Swimming Lessons

Tested strategies to prevent drowning are few. Swimming lessons often are touted as a method to make children safer around water and decrease the risk of drowning death. Some communities have implemented mandatory, school-based swimming lessons for young children. Public high schools in Hawaii have implemented a program that requires students to complete a "drown proofing" course. The technique taught in this course allows for minimal energy expenditure while maximizing survival time. No large studies, however, have evaluated the protective effect of swimming lessons. One study demonstrated that swimming ability and safety skills of preschool-age children were improved through training. Whether this would translate into an improvement in survival during a submersion episode is unknown.

Pool Fencing

Pools are the most important source of drowning for young children. Constant adult supervision is required when children have access to swimming pools. Passive protection strategies also can play a role. Over the last decade, many communities have passed laws requiring the fencing of private and public pools. More recently, studies have examined whether the type of fence surrounding a pool makes a difference. Comparison studies of perimeter fencing (property barrier) versus isolation fencing (around immediate pool area) show isolation fencing to be much more effective in reducing the risk of drowning. Added to this finding are studies that examine children's ability to climb certain types of fences. Chain-link fences, although allowing visibility of the pool area, are the most easily scaled by children as young as 2 years of age. Fence height makes little difference if the child can climb it; one study showed the median time for 4-year-olds to climb a 5-ft fence was 17 seconds. Ornamental iron bar fences have been advocated as a better barrier that reduces "climability" but retains visibility. For a fence that is not scaleable, the most important element is a secure, self-closing gate. Taking these and other findings into account, the CPSC has compiled a list of minimum recommendations for residential pool fencing, available at their Web site (Table 3).

Open Water Drowning

Drowning in natural bodies of water while swimming or boating becomes increasingly prevalent as children move into adolescence. Among teens, alcohol use is associated with as many as 50% of drowning incidents. Efforts to reduce underage access to alcohol, along with multifaceted educational campaigns designed to reduce alcohol consumption while boating, could represent a useful approach to teen drowning prevention and should be evaluated.

The use of personal flotation devices (PFDs) or life jackets also has been suggested as an important method to decrease drowning in open water (air-filled swimming aids such as "water wings" should not be used in place of life jackets or life preservers for children). Unfortunately, because no studies have examined directly the ability of PFDs to prevent drowning, the true magnitude of protection afforded is unknown. One community-based campaign was successful in increasing PFD use from 20% to 31%. Children were most likely to use PFDs if accompanied by an adult using a PFD. Researchers noted that

PFD use was rare among adolescents and young adults. Pediatricians can review safe boating with families at risk and should emphasize PFD use by boaters of all ages, avoidance of alcohol, and dedicated adult supervision of children near water.

Animal Bites

Each year in the United States, an estimated 300,000 to 4.5 million people sustain dog bites, accounting for up to 1% of all ED visits. Children younger than age 10 years are at greatest risk, and most injuries in this age group involve the head and neck. Certain breeds of dogs are overrepresented in severe and fatal dog bites. Fifty percent of the deaths in the United States from dogs are attributed to pit bull-type dogs and Rottweilers, although a great number of breeds were involved in the other 50%. Most dogs are either family pets or are known to the child. Male dogs are sixfold more likely to bite a child than are female dogs.

A variety of preventive strategies has been suggested, including teaching children about dog behavior and distinguishing between a friendly dog and one who is threatened, regulation of types of dogs allowed by homeowners, animal control programs, and educational programs regarding responsible dog ownership and training. Unfortunately, the effectiveness of these different strategies is unknown. Parents must consider the risks of dog ownership, especially those who have small children.

Evaluating Prevention Activities

Recognizing the enormous burden that injury-related morbidity and mortality places on our children, pediatricians have long been active in the field of injury control. It is encouraging to note that United States child injury mortality has declined by 45% in the last 20 years. However, the United States recently ranked 23rd among the 26 most developed nations in terms of child injury death rates, suggesting that room for improvement remains.

Clinicians faced with the common, and often devastating, impact of childhood injury may feel compelled to "do something" in response to this threat. It is incumbent on practitioners, however, to apply the same rigorous standards of evaluation to injury prevention programs as they would to any proposed office-based procedure or community intervention. In an era of competing demands, physicians should consider carefully the value of a prevention program added to their encounters with families. Does the program address an injury mechanism that is common or especially severe? Does it require screening to target its message appropriately? Is there evidence from high-quality randomized trials that the intervention actually reduces injury? Many programs can be demonstrated to change parents' knowledge about injury risk, but does this translate into changes in their behavior or in the risk of injury outcomes? A helpful systematic review of childhood injury prevention strategies is available at the Harborview Injury Prevention and Research Center's Web site (Table 3).

Latinos are the fastest growing ethnic group in the United States. Any injury prevention strategies must take into account children and parents who only speak and read Spanish, necessitating appropriate translation of materials and targeting to high-risk groups.

Finally, pediatricians in practice should recognize that the office is not always the ideal setting for injury prevention. Families at the highest injury risk also are the least likely to have access to ongoing primary care and anticipatory guidance. In many cases, partnership with community or school-based organizations is required to maximize the impact of physician participation in injury control.

Suggested Reading

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PIR Quiz

Quiz also available online at www.pedsinreview.org.

1. The risk of collision injury for 6-year-old motor vehicle occupants can be reduced *most* effectively by use of:

   A. Adult lap and harness restraints.
   B. Airbags.
   C. Booster seats with lap belt and harness.
   D. Helmets.
   E. Rear-facing convertible car seat.

2. The safest method of transporting a 6-year-old child in a moving motor vehicle is in the:

   A. Left rear seat in a rear-facing convertible car sear.
   B. Left rear seat in an adult lap and harness restraint.
   C. Right front seat behind an air bag.
   D. Right front seat in a belt-positioning device with lap belt and harness.
   E. Right rear seat in a belt-positioning device with lap belt and harness.

3. Which of the following interventions has been *most* effective in reducing fatal crashes among adolescent drivers?

   A. Graduated driver licensing.
   B. High school driver education courses.
   C. Limiting the number of passengers in the car.
   D. Prohibition of nighttime driving.
   E. Zero tolerance policy for alcohol use while driving.

4. Bicycle helmets are effective in reducing traumatic brain injury in riders who wear them. Their use is *most* likely to reduce nonfatal head injury in children in communities where:

   A. Bicycle use is restricted to bike paths.
   B. Billboards urge helmet use.
   C. Helmet purchase is subsidized.
   D. Parents wear helmets.
   E. Public service departments size helmets for children.

5. Submersion fatalities among young children can be reduced *effectively* in communities where:

   A. Chain-link perimeter fencing of yards with pools is required.
   B. Gated iron bar isolation fencing of pools is mandatory.
   C. Pool alarms and covers are mandated.
   D. Quaternary health care facilities are readily available.
   E. Swimming lessons for young children are subsidized.

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