Pediatric Injury Control in 1999: Where Do We Go From Here?

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ABBREVIATIONS. ED, emergency department; CT, computed tomography; FIM, Functional Independence Measure.

The problem of injuries to children and adolescents is not a new one. In recent years, however, interest in trauma has increased dramatically for a number of reasons. Advances in the treatment and prevention of a wide variety of acute and chronic diseases have highlighted the importance of trauma as a cause of mortality, morbidity, and disability.[1] An increasingly scientific approach to injury causation over the last 2 decades has led to progressively more effective prevention programs.[2] The interest of government agencies at the national level such as the Centers for Disease Control and Prevention has been accompanied by an infusion of money for both research and prevention. As a result, the scientific and academic communities have taken a greater interest in this problem, and in the last decade, a large number of important contributions have appeared.[3,4]

This article addresses where we have come and where we must go to reduce further the impact of unintentional injuries on children and adolescents in our society. Self-inflicted injuries and injuries attributable to interpersonal violence are not discussed. The publication of this article in the new *Journal of the Ambulatory Pediatric Association* is appropriate, because additional advances primarily will come from investigators in academic centers using basic and applied science and collaborating with clinicians to address the injury problem from the point of primary, secondary, and tertiary prevention.

REDUCTION IN INJURY MORTALITY

There have been some remarkable gains in injury control over the last 2 decades. Data are limited on the true incidence of injuries as well as its consequences; we must rely primarily on mortality data to track trends over time. In the pediatric age group, unintentional injury mortality has fallen by 45.3% between 1979 and 1996 (Table 1). The largest decreases have been among those 5 to 9 years of age, and the smallest among teens. Despite these enormous gains, 13 018 children and adolescents still died in 1996 from unintentional injuries alone, and these must be viewed as preventable deaths.

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INJURY CONTROL

The injury field commonly addresses injury control—the attempt to reduce the consequences of trauma through primary prevention, better acute care, and improved and effective long-term rehabilitation. In each of these three areas, this paper discusses two or three topics that merit scientific attention. The choice of these topics is based on what is seen at the bedside and what the current state of evidence is for control of unintentional injuries.

Prevention

Three areas continue to account for considerable pediatric morbidity and mortality: motor vehicle injuries, drowning, and burns. Additional research into primary prevention strategies is needed in each.

Motor Vehicle Injuries

Motor vehicle injury is the most common cause of serious and fatal injury. Despite the importance of firearm injuries, motor vehicle injuries are the leading cause of trauma death for most ages, including children and adolescents. There have been enormous reductions in motor vehicle fatality rates in this country and other countries of the industrialized world, with a decline in the death rate per 100 million vehicle miles of 69% in the last 30 years.[5] Nevertheless, some major issues remain. In particular, protection of child occupants and prevention of child pedestrian injuries are still problematic.

Restraint Use

During the 1980s and early 1990s, most injury control experts focused on automatic occupant protection, with the greatest emphasis on airbags. Recent data on airbags indicate that for all ages, they reduce the risk of death in frontal crashes by 18% and in all crashes by 11%.[6] However, for children under 13 years of age, airbags actually may increase the risk of death by as much as 34%, especially in low-speed crashes.[6] The risk appears to be a matter of size and position in the vehicle. Smaller individuals such as children and out-of-position occupants are more likely to be struck in the face and neck by the bag as it inflates at 200 mph than are taller individuals.[7–9] Until recently, Federal safety

TABLE 1. Unintentional Injury* Mortality, United States, 1979 to 1996

Age (y)	1979		1996		% Change 1979 to 1996
	N	Rate†	N	Rate†	
0–4	4377	27.24	2895	15.01	−44.9
5–9	2690	15.97	1564	8.04	−49.3
10–14	2966	16.07	1824	9.61	−40.2
15–19	12 664	59.30	6735	36.09	−39.1
All	22 697	31.16	13 018	17.04	−45.3

Data are from the National Center for Injury Prevention and Control, Centers for Disease Control at www.cdc.gov/ncipc.
* *International Classification of Diseases,* 9th revision E 800–869, 880–929, 970–999.
† Rate per 100 000.

standards required manufacturers to test the airbags with an unrestrained 50% percentile adult male dummy, not child dummies. New regulations will require testing of infant and child as well as adult dummies.

Properly used car seats are very effective in decreasing the risk of serious or fatal injury for young children.[10] A larger problem is proper restraint of children who "graduate" from these car seats at age four years or when they attain 40 pounds. Although the American Academy of Pediatrics, the National Highway Traffic Safety Administration, and others recommend the use of booster seats until the shoulder harness and lap belt can be worn safely in a regular seat, few parents use them for their children.[11,12] There has been a need for intervention trials investigating methods to increase booster seat use for the last decade; this need continues today. These trials may require somewhat different strategies from the successful efforts for restraint use in younger children.

Belt use by teens is lower than in other age groups, despite their high risk of serious and fatal crashes.[13] Legislation has made a major difference in increasing belt use, but legislation is not enough. As with preteens, there is a need for implementation and evaluation of concentrated, innovative programs to increase seat belt use in this population. The general risk-taking behavior of teens extends to their lower use of seat belts.

Pedestrian Injuries

There has been a great deal of research during the last 2 decades on pedestrian injuries to children. The mortality from these injuries has decreased by 65% over the last 2 decades and by 45% since 1984,[14,15] but pedestrian motor vehicle collisions continue to be a major cause of serious traumatic brain injury and lifelong disability. The epidemiology of pedestrian injuries has been well investigated, and previous studies have outlined clearly the important risk factors: male gender, age 5 to 9 years with its developmental limitations, poverty, traffic volume and speed, and absence of play space.[16–18] There is little need for additional studies investigating these risk factors.

Attention among investigators interested in child pedestrian injuries has rightfully shifted toward evaluating community level interventions. A major focus of these interventions should be to change the environment to make it safer for pedestrians of all ages, including children. Changes will likely involve some sort of traffic calming, as has been done in Europe and some cities in the United States.[19,20] Studies of traffic calming should be done rigorously, using randomized controlled trials. These can involve randomizing communities, neighborhoods, streets, blocks, or intersections. Given that resources are scarce and not all the needs in a city can be met in the short term, randomization is ethical and feasible.

There are other accompanying research needs. Child pedestrian injuries, although very important, are nevertheless relatively rare events in any one community. As a result, demonstration of the impact of community interventions on child pedestrian injury rates will be very difficult. An appropriate proxy for these events should be developed. The effectiveness of car seat educational programs and seat restraint laws was first evaluated by examining changes in rates of seat restraint use.[21] Likewise, the effectiveness of bicycle helmet programs was measured by determining changes in helmet use over time.[22] A suitable proxy for pedestrian injuries would be clearly related to risk of injury, such as lack of seat belt or helmet use, while at the same time, be much more frequent and relatively easy to measure. Studies testing the reliability and validity of these proxy measures are needed, along with the development of strategies to collect data systematically on these proxy events.

DROWNING

Drowning causes ~1500 deaths of children and adolescents each year in the United States; in some states such as California, it is the leading cause of injury death to preschool children.[23] Its high case fatality rate and the relative lack of impact of medical care on outcome make it a unique injury problem. Approximately 50% of children and adolescents requiring physician care for a submersion incident will die.[24,25] This mortality is enormously higher than any other injury problem, with the exception of self-inflicted gunshot wounds.[26] Drowning also is unique in that survival appears largely dependent on how the child looks when he or she arrives in the emergency department (ED). The child who is spontaneously breathing will almost certainly live, whereas the child who requires cardiopulmonary resuscitation in the ED will almost certainly die or survive with significant neurologic sequelae.[24,27] Medical intervention for submersion victims is at the scene, with bystander cardiopulmonary resuscitation and advanced paramedic life support. A decrease in morbidity and mortality from drowning rests to a great degree on primary prevention.

Toddlers have the highest rates of death in swimming pools or bathtubs.[28,29] Alcohol is involved with as many as 40% of adolescent drownings.[30] However, unlike the motor vehicle injury problem, additional understanding of the risk and protective factors for drowning remains limited. Studies on child or adolescent drowning should identify the presence and magnitude of risks or reduction in risk associated with, for example, pool fencing,[31] swimming lessons and swimming abilities,[32,33] degree of parental supervision, life jackets,[34,35] boating licenses and instruction,[36] size of boats, and many others.

Findings from such studies can have direct and important implications for prevention. For example, a study of bathtub drowning found that seizure disorders in school children and adolescents increased the risk of bathtub drowning 96-fold.[37] The prevention message resulting from this study is simple: children and adolescents with seizure disorders should shower instead of taking a bath. Similar studies of other risk factors can help determine effective and realistic solutions—hopefully beyond telling parents simply to supervise their child better.

The case–control design is probably most appropriate for these studies, because most communities will have too few submersions to investigate risk and protective factors using a cohort or an experimental design. The National Institute on Child Health and Human Development has begun a pilot case–control study recently to investigate the effectiveness of swimming lessons in preventing drowning death of preschool children. Other such studies are sorely needed.

BURNS

Burns have special importance in the injury field. Fires and burns are a common cause of death, with children younger than age five sharing with those at the other end of the life span the greatest risk of dying.[38] For survivors, burns can leave lifelong scars, with tremendous interference in daily life activities.[39,40] Given the current state of burn care (which involves cutting off skin from an unburned area and using it to replace skin in a burned one, resulting in scars at both donor and graft sites) and despite the development of improved care techniques (eg, tissue culture methods), prevention is key to reducing the consequences and costs of burns.

The most common reason for admission of a child to a hospital for a burn is a scald burn.[41] These result from a wide variety of hot food substances, including tea, coffee, cocoa, soup, stew, or spaghetti. Because of the pioneering work of Ken Feldman, tap water scalds have become uncommon.[42,43] However, prevention of the more common types of scalds continues to elude us. No analytic epidemiologic studies have described risk factors for these types of burns, nor have any types of prevention strategies such as wide-based cups or guard rails on stoves been examined critically. The magnitude of the problem indicates the need for such studies. Previous broad-based community studies have been ineffective in decreasing burns,[44] although more recent studies have been more promising.[45]

Acute Care

Acute care of trauma patients takes place from the time of injury through discharge to home or rehabilitation facility. It includes prehospital care by emergency medical technicians and paramedics, care in the ED, and care in the intensive care unit ward and, less commonly, the operating room. Advances in the acute care of patients have clearly made a difference and have contributed to the reduction in injury mortality over the last 2 decades.[46,47] Two areas in which studies are needed to determine more cost-effective care are in the initial management of minor head trauma and in the care of scald burns.

INDICATIONS FOR COMPUTED TOMOGRAPHY (CT) IN HEAD TRAUMA

Head trauma is the major cause of death in pediatric trauma, accounting for 75% or more of fatal injuries.[48] With burns, it is the major cause of long-term sequelae from trauma. One important issue that arises continually in the optimal management of head trauma in children is the issue of when to use CT for a child or adolescent with trauma, and what to do with that information. There is general agreement that children with severe head injury should be examined with CT as soon as feasible.[49] However, there is less agreement on the management of the child arriving in the ED or office with a brief loss of consciousness, the athlete who has his "bell rung" at the high school soccer or football game, or the child in a car crash who is taken to a rural hospital without capabilities for CT and has a Glasgow Coma Scale of 13. The practice of evidence-based medicine will require information on the likelihood of intracranial pathology as well as the therapeutic implications of such information.

First, what is the likelihood of finding an abnormal CT scan in the child with a history of loss of consciousness but a normal examination, or the child with a somewhat, but not alarmingly, abnormal examination? A number of studies, conducted both in trauma centers and community hospitals, indicate that the probability of intracranial pathology among children with a loss of consciousness is ~5%; some of these children receive surgery for these lesions.[50–52] Clinical predictors of positive CT findings unfortunately have low sensitivity and predictive value.

These studies have led to the routine screening of all children with head injury, with accompanying enormous cost. The need for a prospective study of all children with these symptoms, particularly in office settings, is striking. Such a study could be conducted as a large cohort study or even as a randomized controlled trial, in which some children undergo CT and others do not. Key information needs include the true incidence of this problem in the community, the likelihood of finding a positive CT finding, the likelihood of needing surgical intervention, and the difference in outcomes between children who have undergone scanning and those who have not. Without such data, any clinical guidelines on management of head injuries will be flawed. The recent inability of the American Academy of Pediatrics to issue guidelines for the management of minor head injury arose from the lack of such data.

MANAGEMENT OF BURNS

The acute care of burn patients has improved enormously since the famous Coconut Grove Fire in Boston, MA, on November 28, 1942, killed 491 people.[53] The amount of burn area at which 50% of burn patients die is now as high as 80% for children beyond the first year of life.[54]

One of the challenges in burn care lies at the opposite end of the spectrum, namely the care of children with relatively small scald burns involving 5% to 10% of the surface area of the skin. As noted above, scalds are the most common burn to young children and frequently result in hospitalization. In scald burns, it is notoriously difficult to judge the depth of the burn and its ability to heal on its own.[55] As a result, many of these children do not receive grafts immediately but rather are observed for 1 to 2 weeks before making a judgment on need for grafting.[56] Most, if not all, of this observation occurs in the hospital to ensure optimal care of the burn wound. The costs and dangers of overtreatment associated with such care are very high, however. This treatment strategy is reminiscent of previous inpatient care of healthy premature infants until they achieved some magical weight. There is a need for studies, preferably as randomized controlled trials, comparing the benefits, complications, costs, and outcomes of care of these children at home receiving, for example, frequent nurse visits, to care in the hospital. If effective, such home care could empty burn wards.

Rehabilitation

Rehabilitation of injured children and adolescents is professed much but practiced little. One recent national study of >12 000 injured patients reported to the National Pediatric Trauma Registry found that 26% of patients with injuries other than to the head had disability at the time of discharge, and 15% of patients had impairments in four or more areas of functioning.[57] Only 35% had received any rehabilitation care at the time of discharge from the hospital.

Outcomes Research

One of the buzz words in health services research and health care delivery today is "health outcomes." Insurers, providers, health care systems, and patients all want to know how care improves health status, and how outcomes differ with different treatments and different systems of care. Few prospective studies have described the outcomes of the child and family after pediatric trauma, except for patients with head injury.[58,59] The long-term morbidity from other types of injuries to children may be much higher than might be expected. For example, studies of lower extremity fractures in adults found that half of people working before their injuries had not returned to work 6 months later, and nearly 30% were not working 1 year after their injury.[60] One third of patients were disabled in some way 2½ years after injury.[61] Most importantly, there was poor correlation between lower extremity impairment as measured by a physical therapist and persistent disability such as not working, difficulty sleeping, decreased recreation, and emotional problems.

Fortunately, new tools to assess child function are available and should be applied to patients to determine their functional status after trauma. The Functional Independence Measure (FIM) has become part of the uniform dataset for medical rehabilitation and provides a validated, objective measure of physical functioning and rehabilitation needs.[62] A pediatric version of the FIM, called the WeeFIM, also has been developed.[63] Starfield and colleagues have developed the Child Health and Illness Profile—Adolescent Edition, which measures health status across six domains among adolescents 11 to 17 years of age.[64] Landgraf and colleagues at the New England Medical Center Health Institute have developed the Child Health Questionnaire for children 5 and older.[65] This measure of health status across 14 different domains is designed in some ways to be the child equivalent of the widely used short form-36 in adults. These instruments to measure health status in children and adolescents will allow conduct of essential prospective studies to determine the impact of injures on children, how injury severity correlates with outcome, the factors that affect outcome, the relationship of costs to outcome, and the effects of intervention programs.

Intervention Trials

The randomized controlled trial has become the *sine qua non* for therapeutic interventions in medical care. Unfortunately, there are no randomized controlled trials for physical therapy or other rehabilitation programs for injured pediatric patients. The use of cognitive rehabilitation programs for brain-injured children and adolescents is one of the mainstays of their treatment, yet the effectiveness of such interventions has not been well evaluated.[66] Although the frequency and severity of problems such as contractures and infections are much less now than in the past, there are still few data that demonstrate the efficacy of different components of rehabilitation of children with traumatic brain injury.[67,68]

There also are no randomized controlled trials on drug interventions in brain-injured pediatric patients. Posttraumatic seizures are common in children with brain injuries,[69] yet the data on which treatment decisions are based come exclusively from studies of adults.[70] The use of stimulant medication such as methylphenidate for the treatment of inattention and distractibility in head-injured patients is widespread despite conflicting data.[71,72] There are no randomized controlled trails of pharmacologic treatment of agitation in children or adolescents awakening from traumatic coma. Aggressive intervention for the treatment of depression, particularly in adolescents with traumatic brain injury, needs rigorous study.

Randomized controlled trials in this area are not unethical. This is not to suggest that the randomization be between no treatment and a particular intervention. Different types of interventions, among various populations, need to be evaluated using the rigor of the randomized study to arrive at meaningful conclusions. The use of randomly assigned waiting list controls offers another option. To practice cost-effective, evidence-based medicine, physicians first must know what is effective care. Without such information, it is very difficult to monitor both the outcome of the rehabilitation process and the quality of care delivered. Families desperate to help their loved ones will continue to receive deviant or substandard care. The $50 billion annual cost of traumatic brain injury in this country demands the pursuit of these studies.

Systematic Reviews

Since the publication of *Injury In America* a little more than a decade ago,[73] a great deal of research has examined the prevention, acute care, and rehabilitation of injuries. Yet, community groups remain unsure about the best programs to prevent injuries to their children, physicians are uncertain about how best to manage injured children, and managed care organizations need better information about what types of rehabilitation therapy to cover and for how long. Proper review of the literature and its summary using meta-analysis or other techniques could provide answers to many of these questions.

For example, home visiting programs have become popular as a way of increasing social support of new mothers. A systematic review of these programs by Roberts found their use associated with a 26% decrease in injuries.[74] Colloid is used commonly for fluid resuscitation of critically ill trauma patients. However, a recent systematic review of 37 randomized controlled trials found its use actually associated with a 4% increase in mortality.[75] These same systematic review techniques should be applied to many other injury-control problems. Such efforts currently are underway as part of the Cochrane Collaboration, an international effort to conduct and synthesize systematic reviews of the literature. The results of such reviews also can point out the holes in knowledge and needed information to reduce morbidity and mortality to children and adolescents from trauma in the future.

CONCLUSIONS

The increasing focus on basing interventions in medicine on evidence has become a prominent feature of injury control especially in the last decade, with substantial reductions in injury morbidity and mortality over the last 2 decades. Increasing investment in research will expand this evidence base and allow additional effective interventions to be implemented.

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