Child Pedestrian Injuries in the United States

Current Status of the Problem, Potential Interventions, and Future Research Needs

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• Each year in the United States, more than 50000 children are injured as pedestrians, of whom approximately 1600 die, 18000 are admitted to the hospital, and 5000 have significant long-term sequelae. Prevention must rest on a multifaceted approach at the local, state, and national level and should include pedestrian skills training programs, parent education, legislation environmental modifications, and vehicle design changes.

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Each year in the United States approximately 8000 people are killed as pedestrians.[1] Children, particularly school-age children, are the group at greatest risk. Although there has been a decrease in pedestrian fatality rates, pedestrian injuries remain the most common cause of death from trauma for the 5-to 9-year age group and are second only to cancer as the greatest overall killer of young school-age children.[2]

The reasons for the continued toll from pedestrian injuries are many. Pedestrian injuries have not received nearly the attention from the National Highway Traffic and Safety Administration that injuries to occupants have. In addition, the problem is complex and one not amenable to prevention through single interventions, such as car seats, airbags, and motorcycle helmets. Moreover, prevention strategies have often not been rigorously evaluated and tested.

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SCOPE OF THE PROBLEM

In 1985, there were a total of 1852 fatal pedestrian injuries occurring to children and adolescents 0 to 19 years of age, for a rate of 2.6 fatalities per 100 000 population.[3,4] Pedestrian injuries accounted for 13% of all unintentional fatal injuries to children in 1985, with 22% of fatal injuries in 5- to 9-year-olds due to pedestrian injuries. There were distinct age, sex, and, to some degree, racial differences in rates of fatal pedestrian injuries during childhood (Table 1).

Similar national data on nonfatal injuries do not exist. Therefore, national estimates were calculated on the basis of the rates of child pedestrian injuries reported to police in six states (Indiana, Maryland, Michigan, Pennsylvania, Texas, and Washington) and applied to the estimated child population of the United States in each age and sex category. These six states are viewed by the National Highway Traffic and Safety Administration as providing reasonably representative data (G. Hazard, personal communication, October 4, 1988).

There were an estimated 51 062 pedestrian injuries occurring to children and adolescents in the United States during 1985 (Table 2). Males accounted for 60.9% of the total. Unlike for fatalities, the peak age for all pedestrian injuries was the 6- to 9-year-old age group, which accounted for 36.7% of the total.

Pedestrian-motor vehicle collisions are qualitatively different from other types of motor vehicle-related trauma in that very few victims escape injury. Baaed on data from the National Highway Traffic Safety Administration only 1.1% of pedestrians struck by a car are

Table 1.– Fatal Pedestrian Injuries in Children in the United States, 1985*†

Age, y, and Sex	White Victims n	White Victims Rate/ 100000	Nonwhite Victims n	Nonwhite Victims Rate/ 100000
Male				
0-4	265	3.52	103	5.98
5-9	226	3.23	87	5.37
10-14	142	2.00	29	1.74
15-19	303	3.91	51	3.00
Total	936	3.19	270	4.03
Female				
0-4	147	2.06	50	2.30
5-9	126	1.90	64	4.05
10-14	91	1.35	14	0.87
15-19	134	1,60	20	1.21
Total	498	1.78	148	2.27
Total	1434	2.50	418	3.16

*Fatalities from National Center for Health Statistics, Vital Statistics for the United States.

†Population based on Current Population Reports, Series P-25, No. 985, 1986.

Table 2.-Police-Reported Pedestrian Injuries in Children, Estimated US Totals for 1985*

Age, y, and Sex	n	Rate/100000
Male		
0-4	5141	55.70
5-9	12261	142.44
10-14	7789	66.90
15-19	5664	82.30
Total	31075	86.34
Female		
0-4	2593	29.45
5-9	6478	78.66
10-14	5710	68.46
15-19	5206	57.16
Total	19987	59.96
Both sexes		
0-4	7734	42.88
5-9	18739	111.40
10-14	13499	78.93
15-19	11O90	59.78
Total	61082	72.46

*Injuries based on estlmated rates generated from six states (Indiana, Maryland, Michlgan, Pennsylvania, Texas, and Washington), Population based on Current Population Reports, Series P-25, No. 985, 1986.

uninjured.[5] In contrast, 94% of all motor vehicle collisions involve no injury.[2]

Another measure of the severity of pedestrian injury is the case-fatality rate–the proportion of those injured who die. Based on the data in Tables 1 and 2, the case-fatality rate for pedestrian injuries during childhood can be estimated as 3.6%, ranging from 1.0% in the oldest age group to 7.3% for the youngest. In contrast, the case-fatality rate for occupant injuries is 0.5 to 1.0%.'"

An estimated 18 327 children, or 35.9% of the total, are admitted to the hospital each year for the treatment of pedestrian injuries.[5] Conversely, pedestrian injuries are among the most common reasons children are admitted to the hospital for trauma, particularly multiple trauma. Pedestrian injuries account for 31% to 61% of all children admitted for trauma[8-10] and 43% of children admitted to the hospital with multiple injuries.[11] In these severely injured patients, 60% to 79% have head injury. Deaths from pedestrian injury, as with other types of severe trauma in childhood, usually are due to head trauma.[8,11]

RISK FACTORS FOR CHILD PEDESTRIAN INJURIES

Age and Sex

As with other types of childhood injury, boys have a rate of pedestrian injuries nearly twofold higher than that of girls. This increased risk in boys could be due to differences in exposure to risk, differences in behavior, or a combination of the two.[12] The study by Howarth et al[13] indicates that boys have no greater exposure to motor vehicles than do girls. Whether these differences in behavior are due to developmental differences, differences in socialization, or other factors is unknown.[14]

The special vulnerability of the 5- to 9-year age group may in part be explained by the lack of exposure in younger children and the greater developmental skills in older ones. The early school-age child appears to represent a "window of vulnerability" in which expectations and demands of the child as a pedestrian exceed the skills he or she can bring to bear on the crossing task.

Poverty

Studies in Memphis, Tenn,[15] Maine,[16] and Montreal, Canada,[17] indicate that the risk of pedestrian injury is inversely related to socioeconomic status. Poor children in these studies were found to have twofold to threefold greater risks of pedestrian injury than did the nonpoor. The reasons for the increased risk of the poor are probably multifactorial. Most studies seem to suggest that behavioral factors in the child have little, if any, influence on risk of injury independent of poverty.[18] More appropriate attention is perhaps best focused on the child's environment as an important and alterable risk factor and one of the main determinants for the increased risk in areas of low socioeconomic status. These areas are likely to have high traffic volumes and density, higher average and posted speed limits, fewer pedestrian control devices, and fewer alternatives to the street for play.

Pedestrian Action

Although investigators have categorized pedestrian actions leading to injury into more than 30 types, relatively few actions account for the majority of injuries in children.[19] "Dart-out" types of injuries, in which the child darts out into the street in midblock without warning, account for 60% to 70% of the total among children under the age of 5 years and 50% to 60% for those 5 to 9 years of age.[19] Dashing across an intersection is particularly a problem among 5- to 14-year-olds, accounting for 10% to 15% of injuries in this age group. Incidents in which children are run over by a vehicle backing up are limited primarily to the youngest age group, accounting for 5% to 7% of the injuries. Injuries occurring around schools or playgrounds are relatively infrequent, accounting for only 4% to 5% of the total.[20] The majority of fatal injuries to children occur on busy streets or arterials and not on quiet residential streets. Few injuries to children occur after daylight hours.[21]

INTERVENTIONS

Pedestrian injuries are a complex problem, for which no single intervention will be completely effective. Control will require intervention at a number of levels, including federal, state, and local, and involve changes in the host, the agent, and the environment, both physical and social. The evidence for the effectiveness and potential effectiveness of interventions at these various levels is highly variable in both scope and quality.

Pedestrian Skill Training Program

Improving the traffic skills of child pedestrians is not an attempt to place full responsibility for pedestrian safety on the child, but rather an attempt to make the child's behavior more congruent with the task at hand. Street crossing involves a complex series of actions, with as many as 26 tasks needed to negotiate traffic safely.[22] What has been the effectiveness of training programs in improving children's skill at the pedestrian task? The literature is at best confusing, and no definitive answer can yet be offered. Some programs have shown an effect but have limitations of small sample sizes or design problems or have not been replicated elsewhere.

Yeaton and Bailey[23] reported nearly perfect pedestrian behavior with 1 to 3 days of training of 24 children aged 5 to 9 years, effects that persisted for 1 year. No other authors reported such dramatic improvements in performance.

Blomberg et al[24] used a public education campaign focusing particularly on midblock "darts and dashes" ('Willy Whistle") in Los Angeles, Calif; Columbus, Ohio; and Milwaukee, Wis. The authors reported that pedestrian injuries involving midblock darts and dashes by children under the age of 14 years dropped by 18% in Los Angeles and Milwaukee and by 36% in Columbus after the introduction of the program; other types of child pedestrian injuries decreased by 3%. However, the injury reductions appear to be inconsistent with changes in performance. In Los Angeles and Milwaukee, search performance (looking both ways) improved by only 8% and 12%, respectively, while in Columbus it *decreased* by 4%. Furthermore, only 33% of Los Angeles and 20% of Milwaukee elementary school children saw the instructional film. Thus, the reported effect of the program on changes in injury rates must be questioned.

Fortenberry and Brown[25] reported on a school-based pedestrian safety program in four Alabama cities. There was a 33.8% reduction in pedestrian injuries involving 6- to 7-year-olds after the in-

tervention, compared with a 5% reduction in pedestrian injuries for other age groups. This is a fascinating report unfortunately, no details of the program were given to allow it to be replicated elsewhere.

Some types of interventions have been shown to be more effective in at least altering behavior than others. Training in *real traffic situations* appear to be substantially better than training in a school yard or child-size village ("traffic garden'').[26,27] Use of a potentially safer, roadside simulation with nine to 12 training sessions during a 6-week period has been successful in teaching young children how to use gaps in traffic in crossing safely.[28] Theoretical instruction in the classroom alone does little to affect behavioral performance, although it may improve knowledge and understanding of the traffic task.[26] Several authors have advocated behavior modification for pedestrian skill improvement.[27] However, the effectiveness of these techniques alone without accompanying practical training are unknown.

In summary, a number of promising reports on programs designed to improve children's pedestrian skills have appeared in the literature. The literature is also replete with examples of programs that have been ineffective. At present, there is no well-developed and packaged curriculum that can be easily transferred to the school setting and that consistently produces large increases in correct pedestrian behavior by children in high-risk age groups.

Parent Involvement

Parents must be a key element of any community-wide program designed to reduce child pedestrian injuries, for two reasons: parents set the expectations for children's performance in traffic and parents can extend and reinforce any educational efforts begun in the schools.

Surveys performed in Europe suggest that parents have unrealistic expectations of their children's pedestrian skills. A survey performed by Foot et al[29] in England indicates that the majority of parents, teachers, and police officers place the blame (and hence the responsibility) for pedestrian injuries on the child, In a US survey, 78% of 1- to 6-year-olds playing near the street were unsupervised by an adult.[30] One of the causes of child pedestrian injuries may be a relative mismatch between the skills and knowledge of the child and the expectations of parents and society of these children.[81] Thus, one of the key elements in a prevention program may be to give parents a more accurate perception of the complexity of the task and the developmental limitations of children, especially young school-age children.

Parents can play an effective role in training children in safe street crossing. Limbourg and Gerb[32] in Germany developed a step-by-step training program for parents of 3- to 7-year-old children. Without training, 90% of children crossed without stopping at the curb and without looking. The parent training program was able to reduce this significantly. Rothengatter[27] demonstrated that parents were as successful as trained teaching assistants in improving the traffic behavior of young children.

Legislation and Enforcement

Legislation has been an effective component of many injury control programs, especially those related to motor vehicles. The extent to which laws and enforcement play significant roles in pedestrian safety, however, is a question that remains to be answered. Some authors advocate radical changes in attitudes towards the primacy of pedestrians, particularly child pedestrians, and a move away from the attitude of "motor vehicle as king."[33]

Clearly, some recent changes in laws increase the risk to pedestrians. Right-turn-on-red is one example; Zador[84] found that child pedestrian injuries were increased by 30% after adoption of this law. The effect of other laws on increasing the risk to pedestrians is unknown.

Examples of legislative approaches in other areas of motor vehicle safety indicate that enforcement is a key component for effectiveness. Lack of understanding of pedestrian laws and their enforcement may be a major reason for noncompliance by drivers in many areas of the country. In a survey of 41 states on legislation affecting pedestrian/vehicle interactions, with the exception of California, enforcement of pedestrian safety laws receives little emphasis and is regarded as politically difficult.[35]

In many states where laws are enforced, the emphasis has been traditionally on the pedestrian, rather than the driver. For example, in one Western city, 8000 citations were given to pedestrians for "jay-walking" but less than 600 to drivers involved with pedestrian-motor vehicle conflicts. In Pennsylvania, changes in the Pennsylvania Vehicle Code in 1977 resulted in virtually no change in driver behavior with regard to pedestrians because the law went virtually unenforced.[35]

Environmental Modifications

Changes in the environment have been a traditional component of injury prevention programs, including those for pedestrian safety, for many years. A number of potential interventions have been examined.

Speed bumps have been suggested as a means of preventing injuries by decreasing the speed of vehicles, particularly in residential areas. However, Allen and Walsh[36] demonstrated that speed bumps were not effective in reducing vehicle speed and are a hazard to vehicles such as bicycles and motorcycles. Furthermore, at least one study indicated that the majority of pedestrian injuries involving children occur on arterials, and rarely in residential neighborhoods.[21]

Painted crosswalks have been used for many years as a method of increasing pedestrian safety while crossing streets. However, the evidence of their effectiveness in decreasing the risk of pedestrian injury is limited. In fact, one study showed that, controlling for exposure, pedestrians using marked crosswalks have twice the risk of being struck by a car than those in unmarked crosswalks.[37] This is particularly a problem for children, in whom crosswalks may create a false sense of security by inducing them to believe that the driver sees the child and will in fact stop. Other authors, conversely, have found that marked crosswalks decrease the risk of injury, while pedestrians crossing the road within 50 yards of a marked crosswalk are at a significantly increased risk of injury.[38]

The success of separation of pedestrians and motor vehicles temporally as

discussed above depends on both driver and pedestrian knowledge and observation of pedestrian laws.[88] In contrast, separation of pedestrians and motor vehicles spatially may offer a more automatic, ie, passive, intervention.

The main method of separation, particularly for children, is sidewalks and pedestrian paths. Empirically, sidewalks appear to be effective; in England, less than 4% of child pedestrian injuries occur on sidewalks.[38] Their use, particularly in rural areas and new housing developments, should be encouraged if not legislatively mandated.

Pedestrian underpasses and overpasses offer an obvious separation of pedestrians and traffic. Their effectiveness is limited by the relatively low use of these devices by pedestrians and the very large cost for construction. Other, relatively low-cost changes in the environment can be suggested. Conversion of two-way streets to one way systems will decrease confusion for both driver and pedestrian and can decrease the risk of injury.[39] Parked cars present a special risk for child pedestrians, by virtue of blocking both the view of the child and the view of the driver. Restricting curb parking, especially near crossing locations, can potentially decrease the risk for children.

Vehicle Design

The majority of injuries occurring in a pedestrian-motor vehicle collision are due to the pedestrian being "run under" by the car and thrown up onto the car, rather than being "run over" and contacted only by the wheels and pavement. Changes in motor vehicle design have been effective in decreasing the incidence and severity of motor vehicle occupant injuries. Research over the last decade indicates that similar design changes to the exterior of the vehicle can potentially reduce the risk of serious injury by one-third to pedestrian who are struck. [40]

The Driver

The driver is the obvious second individual in any pedestrian-motor vehicle collision. How much do his or her actions contribute to the collision, and can these actions be changed?

Without attempting to ascribe "blame," the driver's failure to search and detect the crossing pedestrian or to judge correctly the pedestrian action was found to be a factor in nearly one third of pedestrian-motor vehicle collisions.[19] The study by Baker et al[41] of drivers involved in fatal pedestrian collisions indicated that 46% were probably negligent and contributed to the collision. Although the pedestrian was negligent in 60% of cases, the driver was *also* negligent in nearly one quarter of these cases. Fifty-eight percent of the drivers who were probably negligent had poor driving records before the pedestrian crash.

Other studies have shown that a significant proportion of drivers who are at fault are impaired in some way, usually from alcohol.[42] Unfortunately, many studies do not report results of alcohol tests on a substantial portion of drivers, so that the actual rate of alcohol involvement is unknown.

The extent to which driving behavior can be modified to reduce the risk of pedestrian injury is questionable. In the study by Baker et al, 23 of the 180 drivers who killed pedestrians had been previously assigned to driver rehabilitation clinics.[41] In addition, the rate of speeding convictions in the 4 months *after* the fatal collision was as great in this group as before the collision. It is difficult to imagine a more potent stimulus for behavior change than killing a pedestrian, yet even this was ineffective for many drivers.

FUTURE RESEARCH

The fact that for many of the areas described above there are no well-proved, effective interventions speaks for itself about the need for more research in this area. Much of the previous work has been descriptive. There is a need for more analytic studies, using case-control designs and randomized clinical trials to evaluate the risks for injury and the effectiveness of interventions. Many of these interventions will of necessity be large-scale, community-wide programs in which the outcome measure should be child pedestrian-motor vehicle collisions.

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Book Review

The Death Shift: The True Story of Nurse Genene Jones and the Texas Baby Murder by P. Elkind, 351 pp, $19.95, East Rutherford, NJ, Viking Press, 1989.

Despite this book's sensational subtitle, *The True Story of Nurse Genene Jones and the Texas Baby Murders,* Elkin's style is much more like that of Berton Roueche, the author of *Eleven Blue Men,* than that of a tabloid. Hand over hand, he pulls himself and the reader along a chain of tragic events occurring in a pediatric intensive care unit (PICU) and a pediatric practice in San Antonio in 1980.

Injecting succinylcholine in the place of immunizations, a licensed vocational nurse (the Texas equivalent of a licensed practical nurse) converted routine visits to the office of a young pediatrician into "codes." She elbowed experienced emergency medical service personnel aside in a helicopter and gave lethal injections to an infant in front of them, then took credit for early recognition of the "deterioration" that they failed to detect.

In the PICU Jones' patients had a high incidence of unexpected hemorrhage on her shift, attributed to "disseminated intravascular coagulation" until it became apparent that surreptitious doses of heparin were given during the 3 to 11 PM shift. One attending physician, after watching a patient recovering from an episode of diarrheal dehydration come close to death from a sudden, uncontrollable hemorrhage that was stopped only by large doses of protamine, refused to permit the infant to remain in the PICU and demanded the still critically ill child be transferred to a general ward. He went home well a few days later.

Despite the suspicion of many nurses and physicians and two internal investigations, the hospital and medical school authorities not only failed to stop the killer but relieved the pediatrician in charge of the unit, accusing him of sloppy administration and "burn out." Nurses who spoke out against Jones were "allowed" to resign. When things got too hot Jones accepted a job offer from a graduating pediatric resident and was sent on her way with a letter of reference indicating that she was "loyal, dependable, and trustworthy." The letter was composed by the nursing administrator for pediatrics and the head nurse of the PICU, both of whom had participated in the internal investigation and had engineered the displacement of Jones from their PICU by creating a policy that made it an "all RN" unit. The soon-to-be banished PICU director, a handful of staff nurses, and one surgeon raised the alarm but the people in charge failed miserably to support them. Elkind offers plausible, and acceptable, reasons for each of these failures; they can be summarized as displacement of the best interests of the children with self-interest.

The author's effort to explain Genene Jones is in two parts: a description of her childhood (chapter 2) and a description (in the last chapter) of Munchausen-by-Proxy syndrome. The reader must reach his own conclusions concerning the relevance of the former; the latter deserves our undivided attention.

Jones, described by her mother as a "pathological liar" and by a psychiatrist as having no psychiatric disease, cut through the protective barrier of caretakers with remarkable ease.

Those of us who are responsible for protecting children cannot plead ignorance of the fact that some caretakers are evil. If there is anyone who remains incredulous, please read this book.

Genene Jones is in a Texas penitentiary sentenced to 99 years for the murder of an 18-month-old child. She is eligible for parole in 1990. There are pictures of Jones in ***The Death Shift.***

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