

REVIEW ARTICLE

Developmental risk factors for childhood pedestrian injuries

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'The automobile is the natural predator of the child' Burton H Harris, MD

Pedestrian injuries remain a significant public health problem for children.¹ In 1992 in the United States, more than 600 children younger than 16 years of age died² and an estimated 31 000 were non-fatally injured³ from pedestrian injuries. In that country, pedestrian injuries account for 6.3% of childhood fatalities from all causes between 1–14 years, and 9.3% of deaths from all causes in children between 5 and 9 years, the highest risk group in childhood.² The childhood annual pedestrian death rate in other industrialized nations is similar: Australia 3.1,⁴ New Zealand 3.0,⁵ and the United Kingdom 2.4⁶ deaths per 100 000 persons between 1 and 14 years old.

Why are children, especially young children, at such high risk? Childhood pedestrian injuries result from a highly complex interaction of many possible factors.⁷ A full analysis would include risk factors related to the child, the driver, and the environment (table). In this review we consider only one aspect of the problem: *the developmental attributes affecting the behavior of children that make them more likely to be struck by a vehicle.* We address the

normal developmental stages of children, how children of various ages behave in traffic, what tasks and skills are needed to negotiate traffic successfully and which are deficient, and the effectiveness of school based methods intended to correct such deficiencies.

Stages of cognitive and psychosocial development: relationship to risk of pedestrian injury

Young children are, by their nature, more at risk than most adults in traffic. They are likely to be exposed to traffic threats that exceed their cognitive, developmental, behavioral, physical, and sensory abilities.⁸ Development occurs continuously, rather than discretely in steps. The age at which a certain stage is reached varies among children, as may their abilities at the outset of any stage. Because injuries are reported and tabulated according to a chronological rather than developmental scale, relating injury risk to stage of development is difficult, yet is valuable to consider. Most work related to the cognitive development of children is founded on the developmental theory of Jean Piaget.⁹ He described four stages of development that were based on a child's ability to solve mental problems from infancy through adolescence: sensorimotor intelligence, preoperational, concrete operational, and formal operational stages.

Some factors associated with child pedestrian injuries

Factors related to the child

Stage of development, behavior, and cognition

- Short attention span
- Irregular walking speed
- P propensity for midblock dart-outs
- Anatomic development and physical attributes^{58 86}
- Relatively short stature (more difficult to see and be seen)
- Use of reflective clothes
- Sudden appearance in the roadway
- Social environment
 - Effect of others on crossing behavior⁸⁷
 - Crossing guards
 - Parent or other accompanying adult
 - Older sibling or peer
 - Adverse family factors^{38 88}
 - Poverty
 - Crowding
 - Placement in the care of local authorities

Factors related to the driver

Influence of seeing a child in or near the roadway^{89–91}

Use of alcohol¹⁹

Driver fatigue⁹²

Factors related to the environment

- Type of road⁹³
 - Driveway, parking lot, freeway, major or minor arterial road, collector road, local street
- Layout of road⁹⁴
- Traffic signals and traffic islands
- Adverse traffic conditions
 - Traffic density and vehicle speed^{7 95–98}
 - Home and neighborhood characteristics⁹⁸
 - Roadside parking
 - Vehicle design^{99 100}
 - Inclement weather
 - Darkness¹⁰¹

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SENSORIMOTOR INTELLIGENCE STAGE

This first stage extends from birth to about 18 months, during which time the infant builds concepts by interacting with the environment. Responses that were originally based on instinct become shaped by acquisition of knowledge concerning properties of objects in the environment. For example, if a mobile is more interesting to infants after they make it move, they will touch it more often. Infants begin to perceive themselves as causal agents, and eventually learn to behave in a manner needed to achieve their desired outcome.

Epidemiologic studies note that young children are at increased risk of pedestrian injuries in driveways¹⁰ and other relatively protected areas. Two factors contribute to this risk. First, children may be drawn toward, rather than away from, moving vehicles. Second, infants have not yet fully developed the concept of object permanence — that an object still exists even though it has been moved out of sight. To

an infant, then, a vehicle parked in the garage may not exist if it cannot be seen from where the infant sits in the driveway, or if it is located beyond a blind bend in the road. Fortunately, object permanence in children begins to emerge slightly before they begin to walk.

PREOPERATIONAL STAGE

The second stage of development described by Piaget spans from about 18 months to 7 years. Such children acquire symbolic operations, including the ability to imitate in the absence of a model, form mental images, draw and play symbolically, and use language. These enhance the ability to fantasize, allowing children to escape the immediate environment and experience new events. During this time, motor skills expand, including running and jumping. The capacity for fantasy and increased locomotor skills broaden the child's range of expression. For example, a child may play simultaneously the role of fireman, fire truck, hose, ladder, engine, siren, burning building, and the occupants of the building.¹¹ Such enhanced activity, in concert with a separation from reality and its attendant restrictions, places the child at increased risk of pedestrian injuries, for how can a soaring airplane be concerned with where the road begins?

Early studies reported that children in the preoperational stage could not depart from their own point of view (egocentric thinking).¹² In the child's view, the world centers on him, so if he can see himself, the world also can see him. For this reason, preschool children may have difficulty imagining that a driver cannot see them standing between parked cars. Similarly, children see no need to assess traffic before running across the street, because, from their point of view, the environment exists to serve them. Early studies also reported that children at this stage used only the most fundamental systems to classify an object (rigid thinking). For example, a preschool child presented with two clay balls of equal mass will recognize that they have equal amounts of clay, if they are both shaped as spheres. However, if one is flattened, the preoperational child will think it has more clay because it has a larger circumference, since size is a fundamental means of classification for children of this age. Using this rigid system of classification, a child may perceive all wide streets as dangerous, but all narrow streets as safe, because size is the only basis for classification.

More recent theory uses a 'constructivist' approach to understanding cognitive development. In this approach, humans are 'active processors of information who construct their own reality . . . through active physical and mental manipulation of the environment.'¹³ Witness that the preoperational child can, in fact, have more than one perspective if the cues provided are familiar.¹⁴ For example, children between ages 2 and 5 were able to take the perspective of familiar Sesame Street characters rather than their own.¹⁵ With appropriate prompts, then, it may be possible to enhance young children's ability to evaluate whether a

driver can see them. They correctly organize knowledge into categories based on a variety of criteria, but these categories are based on what is practical, rather than what is logical.¹⁶ Rather than centering on one characteristic, they use cues, such as a set of painted white lines on a street, to generalize and thus define a category called 'a safe place to cross'. Categories are learned hierarchically; basic level categories are learned first (for example, car), while subordinate categories (for example, make) and superordinate categories (for example, transportation) are developed later. The child can make sophisticated distinctions among categories, but their developmental order must progress in proper sequence. For example, a child must learn to distinguish 'road' from 'non-road' before she can distinguish a highway from a dead-end street. Until the preoperational child learns the full breadth of categories in this hierarchy, the capacity to learn safe pedestrian behavior is limited.

Several other developmental features make it difficult to train the preoperational child to deal with traffic successfully. Cause and effect do not exist, so children at this stage cannot comprehend that their actions have demonstrable consequences. They tend to center their attention on one characteristic, to the exclusion of other features that are often more important. A child may be more interested in the color of an onrushing car rather than its speed or proximity. Finally, the preschool child distorts facts to create a personal reality. For example, a child playing a game may incorporate an approaching car into his game, or think that he has the magical power to stop the vehicle.

CONCRETE OPERATIONAL STAGE

The third stage spans from about 7 years to adolescence. Attention has been focused on three of the conceptual skills such children acquire — skills of conservation, classification, and combination. Conservation, the ability to determine, for example, that the same amount of clay is present whether it exists as a ball or pancake, is now established. Classification skills are structured according to principles of logic. During the concrete operational stage, children will form a hypothesis and use it to guide their classification system until it fails, at which point they will form a new hypothesis. Such skills greatly enhance the ability to identify dangerous situations. However, performance is inconsistent while these skills are developing. Similarly, the child who can classify well in one dimension may have difficulty classifying in another dimension. For example, a child may be able to conserve the mass of the clay objects, but not be able to transfer this concept to their weight. Difficulty arises when dealing with complex or combinatorial situations, which require simultaneous processing of more than one feature. Thus, a child may have difficulty determining whether it is safe to cross the street between two parked cars (learned as dangerous) when the cars are located on a crosswalk (learned as safe).

The concept of proportions begins to

develop only at the end of the concrete operational stage. This has several ramifications. First, because probability is a form of a proportion, most children in this third stage will not be able to distinguish between a low and a high probability event, and thus cannot understand risk. Second, an event that results from the confluence of several factors (for example, a car careering off a bridge, with failure of a safety belt to unlatch and consequent trapping of the occupant, resulting in drowning) may be considered just as likely to occur as one that results from one factor (for example, a child killed by stepping in front of a moving bus).

FORMAL OPERATIONAL STAGE

The final stage of cognitive development begins in adolescence. For the first time, youths can think abstractly about events not previously experienced or even contemplated. Their decisions can now be based on simultaneous consideration of two or more variables. In terms of pedestrian skills, it now becomes possible to judge both the speed and the distance of an oncoming car. Behavior is now viewed as the initiation of a chain of events, rather than the occurrence of a single, immediate outcome. As in the previous stage, these cognitive characteristics develop slowly, and are manifested inconsistently at first.

Interaction of psychosocial and cognitive development

Aspects of psychosocial development and cognitive development occur in tandem and may interact to modify the risk of injury. For example, acquisition of self control (impulse control) is a hallmark of the toddler's psychosocial development. This helps reduce the risk associated with increased locomotion and fantasy. Likewise, the rigid understanding of, and adherence to, rules by children in the early phase of the concrete operational stage may enhance their safety as their pedestrian domain broadens from home to neighborhood and school. However, rigid adherence to rules does not always lead to greater safety, because inability to generalize from a specific circumstance addressed by the rule to other somewhat similar situations not specifically addressed may put young children at greater risk when they encounter a new circumstance. Too, the aggressive, outgoing, defiant behavior stereotypical of 3 year old male toddlers likely increases their risk of pedestrian injury by emboldening them.^{17,18} Later, during the middle phase of the concrete operational stage, children characteristically enjoy undertaking dangerous adventures with friends. However, this phase may occur before the concept of proportions (risk) is acquired, leading them to take risks they cannot gauge and to consequences they do not expect.

How do children behave in real traffic?

Children may be injured while standing, walking, or playing on the sidewalk or curb,¹⁹

driveway,¹⁰ or street.²⁰ However, most behavioral studies have examined crossing the street, because this is the activity associated with most injuries.²¹ This task can be divided into two phases, precrossing and crossing. Development is especially relevant to the precrossing phase, including selection of the moment to cross, which involves observation, perception, judgment, and decision, and selection of the site to cross.²²

Early data concerning street crossing skills were obtained by observing elementary school children crossing near schools.²³ Before entering traffic, only 40% of American children were observed to search to the left, fewer than 30% to the right, and 5% behind. Fewer than 35% stopped at the curb before crossing, and 20% stepped into danger. About 15–20% did not cross within the crosswalk area, and 10% played in the street while crossing. About 30% ran across the street. Grayson noted that 39% of child pedestrian casualties in the United Kingdom had not looked at all before crossing, and another 21% had looked but not recognized an imminent threat before crossing.²⁴

The crossing behaviour of children appears to differ substantially from that of adults.²⁵ Adults base crossing decision on the best *time* to cross, while children base it on the best *place* to cross. In one study, most children preferred to cross the street where a traffic island was located, presumably because it simplified the task by dividing it in half. However, adults seldom preferred to cross at that site, perhaps because it might take longer to cross. Adults begin observing and judging traffic long before reaching the curb, which enables them to hesitate less at the curb. They then cross diagonally at midblock, following closely behind the last vehicle that passes them. This maximizes the gap distance to the next oncoming vehicle. Those children who do observe traffic before crossing tend to stop at the curb at midblock before assessing traffic, which increases curb delay. They then cross the road at right angles to the curb, preferring the shortest distance to the shortest time. The adult pattern is adopted by children by 11–12 years of age. The adult pattern, although more efficient, probably increases exposure to traffic because of the additional time spent in the roadway.

What necessary traffic skills do children lack at various ages?

Precrossing skills include planning the route, detecting traffic, making a judgment about its threat, and making a decision about whether and how to cross. Crossings skills principally involve motor development and continuous feedback about decisions made. In considering the following studies, the reader should be cognizant of several facts. First, experimental studies, such as those discussed below in which children are presented with a real or simulated roadway, assume that the child looks for traffic and recognizes traffic after seeing it. In fact, however, fewer than 40% of the children struck do both.²⁶ Second, simulated studies or performance tests supervised by adults may not instill

the anxiety or confusion that may occur in real traffic, thus overestimating the child's ability to perform. Third, most experimental studies do not present complex threats that are more realistic, such as several vehicles travelling at different speeds or in different directions. These are likely to be even more difficult for the child to judge.

PLANNING A ROUTE

Planning a safe route is difficult for young children up to 9 years old. Even then, there may be some problems in finding a safe place to cross a road. Younger children favor the most direct route over seeking the safest places to cross. Accordingly, the young child may cross in midblock at right angles to the curb, but cross an intersection diagonally rather than performing a two part right angle crossing.

DETECTING TRAFFIC

Detecting traffic requires sensory acuity and correct processing of sensory information. Because the automobile is a moving stimulus, detection requires a search strategy. The ability to search systematically begins during the concrete operational stage, but is not reliably present until the end of this stage, about age 11.

To detect traffic, most pedestrians use visual and auditory cues. Visual perception incorporates visual acuity, scanning ability, use of full visual fields, and color perception. Visual acuity is well developed by 6 months of life,^{27,28} but children may have tunnel vision and thus be unable to process information from their peripheral fields of vision.²⁹ The short stature and lower eye level position of young children may further limit their field of view. The ability to abstract color as a property begins at about 3 years of age. Between 3 and 6 years, color is preferred over form as a basis of categorization, after which color becomes subordinate.³⁰ The ability to match by color does not necessarily signify an ability to identify colors,³¹ which may be important when teaching young children to discriminate traffic signals. Older children, however, use color beneficially. Under experimental conditions, search times of 7–12 year old were substantially reduced when color cues were introduced.³²

The ability to scan effectively is poorly developed in young children.³³ When children between 3 and 6 years of age were presented a picture, the youngest children fixated on its center with very little eye movement. When they were later asked whether they recognized a picture, they made large visual sweeps beyond its boundaries. With increasing age, however, they progressively fixated on fewer features, used fewer eye movements, had shorter search times, and misidentified less often. The duration of fixation also decreased with age, suggesting that older children process visual information more quickly.³⁴

Sounds can provide vital clues in traffic, including tire or engine noises made by an oncoming vehicle and skidding tires or a honking horn indicating impending danger. Six year

olds appear to be substantially less able than adults to detect the simulated direction of an oncoming vehicle.³⁵ Sensitivity to sound may depend on age, increasing through age 12 and declining thereafter.³⁶ Children with deficient hearing or visual acuity may be more likely to sustain a pedestrian injury than those with normal sensory acuity,³⁷ although another study refutes this.³⁸ Even the brain hemispheres may differ in the accuracy with which they process sound signals received from their designated ear on the contralateral side. It appears that the right ear/left brain combination performs better in this regard than the left ear/right brain in young children.³⁹

PROCESSING SENSORY INPUT

Once traffic is seen or heard, it must be heeded. The first step is to recognize its importance. Young children cannot rapidly identify and discard irrelevant, distracting cues. Before the stage of formal operations, children lack the ability to concurrently process more than one feature of a situation. Young children more readily attend to incidental aspects of a visual field during scanning, especially if it is new, surprising, or something with which the child is emotionally involved.^{40–42} Before age 5, control of attention is almost lacking; after that, irrelevant information is not always ignored. Before age 6, children may not have an automatic search plan. Children 6–7 years of age can learn which situations call for a planned, systematic search, but they may not focus sufficiently to conduct this search until they are about 11 years old.^{43–45} Such developmentally normal attention deficits cause the young school age child to be unreliable in traffic.

MAKING CORRECT JUDGMENTS ABOUT TRAFFIC THREATS

Crossing decisions include whether or not to enter the roadway, the place to cross, the path to take, how fast to travel, and how the driver might react. A sound decision on whether to enter the roadway should be based upon recall (experience) and monitoring of the traffic detected, including the distance, speed, and anticipated direction of vehicles and the opportunities provided by various gaps in traffic. The time that has elapsed while making the decision also needs to be incorporated. Successful crossing performance also requires reliable estimation of the pedestrian's walking speed, peak capabilities, and distance to the other side of the road or a traffic island. Integrating all these aspects is difficult for the child, especially one inexperienced in traffic, and result in a longer decision making time. In fact, a 5 year old requires about twice as long to reach a pedestrian decision as an adult.⁴⁶ This leaves even less time to execute an imperfectly planned crossing.

Vehicle distance

Before the concrete operational stage begins at about 7 years, the child's system of

classification is based on familiar and obvious traits such as size. Assessment of distance depends in part on comparing the size of the vehicle to objects located near to and far from the observer, using the memory of the absolute size of a vehicle from previous encounters. Unfortunately, children have a limited ability to correctly retain the true size of an object ('size constancy') as it is moved farther from them, with the limit of accuracy reached at about 60 feet.⁴⁷ Vinjé⁴⁸ suggested that the Piagetian concept of overconstancy⁴⁹ may be partly responsible: the mind interprets a small object located nearby as having the same size as a larger object farther away, and consequently, the distances from the observer are erroneously considered to be equal. This overestimates the distance between the child and the smaller object, putting the child at imminent risk. Adults tend to underestimate actual distances, which may be partly protective.⁵⁰ Compared with adults, children vary more in their determinations of distance, and children make such determinations less efficiently.⁵¹

Vehicle movement

Until age 8, it is difficult for a child to process all the information needed to determine whether a vehicle is moving. The concept of motion is associated with a more fundamental category of classification, size, and is assessed by making repeated estimates of vehicle size relative to other objects. Since young children have difficulty estimating size, their assessment of vehicle movement is unreliable.

Vehicle speed

The concept of speed is even more complex because it incorporates the ratio of distance per unit of time. Piaget believed that the child's concept of movement and speed is closely related to his concept of time, which begins in the earliest (sensorimotor) stage but is not complete until the concrete operational stage (7–11 years).⁵² Because children in the preoperational stage have not mastered the ability to assess distance or time, accurate determinations of speed are well beyond their capability. Furthermore, their assessment of their own walking speed used to cross the road is influenced by fantasy, for example thinking 'I am as fast as a jet'. Even though concrete operational children have begun to consider the concept of distance, and their assessment is less likely to be affected by fantasy, they are still not proficient in dealing with combinatorial classification of more than one attribute, such as distance and time. The concept of a ratio or proportion is thus beyond their reach. For several reasons, then, the determination of speed is not reliable until the last stage.

Piaget's theory of children's skills has been validated by studies demonstrating that until the age of 8, young children do not assess speed well. Children younger than 8 believe that whichever vehicle passes more objects is traveling faster, regardless of the time needed to do so.⁵³ Fast speeds are more difficult to correctly ascertain than slow or medium speeds, even for

older children. Children may suppose that compact cars inherently travel faster than bigger, quiet cars.⁵⁴ Even at age 9, only 75% of children could correctly judge which of two trains traveled faster, given identical starting and stopping times but different routes of differing lengths.⁵⁵ The misbeliefs about speed are compounded by the absence of a reference base of likely motor vehicle speeds. In one study only about 60% of children 4–7 years old even knew what speed to expect from various vehicles.⁵⁶

Gap acceptance

Gap acceptance refers to the pedestrian's view of whether there is sufficient time to safely cross the road and avoid a collision with the next oncoming car. This judgment takes into account vehicle distance, roadway width, vehicle speed, and walking speed. Too short a gap acceptance results in a 'tight fit', either as crossing begins or ends. Accepting too long a gap results in rejecting valid (missed) opportunities. Children's abilities in gap assessment have been studied by showing them video recordings of approaching vehicles, by using a 'pretend road' adjacent to but protected from a real road, and by unobtrusively observing real crossings. In general, young children err in both directions: compared with adults, children miss more opportunities and have more 'tight fits' as they enter the roadway.⁵⁷

Impulse control is an important feature of gap acceptance. Young children have difficulty suppressing sudden impulses and are likely to run into the road, appearing suddenly without warning.^{58,59} In one series, the midblock dart-out was the leading cause of pedestrian injuries, constituting 24% of all pedestrian injuries. About 90% of these dart-outs occurred in children younger than 14 years.²¹ Between 5 and 7 years, the child learns to suppress the first impulse, in favor of a later response.⁶⁰

Anticipating driver behavior

Compounding young children's limitations in assessing traffic is the child's inability to anticipate driver behavior or to evaluate their own role in communicating their intent to drivers. While current research suggests that young children can adopt a perspective other than their own, this appears to be limited to the perspective of familiar others. Because the role of driver and often the person driving are unfamiliar to the child, young children cannot anticipate driver actions very well. Moreover, only in adolescence do youths begin to understand that their own behavior can initiate a chain of events. Therefore, younger children do not assess very well the importance of their own role in making the driver aware of their presence. The egocentricity of school age (or younger) children also makes it difficult for them to imagine that the driver might be unaware of their presence. The situation is further exacerbated by the propensity for impulsive behavior in young children. While striving for self control begins at age 2, it is not consistently effective before age 6 or 7.

Causality

The young child's understanding of causality in social relationships is age dependent. For example, they may believe that adults will always be kind to them, and therefore, that drivers will be able to stop instantly if necessary. Magical thinking may lead them to conclude that nothing bad will happen to them, or that bad things can be avoided by such simple means as crossing one's fingers.⁶¹ True rational causality does not appear until age 7 or 8⁶² and not until adolescence can youths consider their own legitimate role in the causal chain.

Crossing the street

A child's ambulatory ability is related to motor development. At age 3, most children walk automatically, can run, jump from a height of 1.5 feet, and have fairly good balance. During the next year, the child acquires a steady pace and gait and can walk backwards.⁶³ By 5 years, the child can start efficiently and stop quickly, can negotiate sharp corners, and becomes more graceful and strong.⁶⁴ Because these motor skills develop fairly early in life, they do not seem to impede a child's ability to negotiate traffic after the sensorimotor stage.

Developmental considerations when teaching pedestrian skills

Several general educational approaches exist, including: teaching traffic safety by having children memorize a short poem or list of rules; using audiovisual aids, print, and electronic media; using table top or other indoor demonstrations; using miniature street simulations ('traffic gardens' and 'safety towns'), and real, yet protected, traffic situations, such as a 'pretend road'. Several authors have reviewed the effectiveness of these methods, though few programs have been carefully evaluated.^{65,66}

Obedying rules is an age dependent phenomenon. Because preoperational children have so many difficulties making traffic related decisions, their decisions are principally rule based. Their personal safety depends on learning and strictly obeying crossing guidelines, such as 'only cross when an adult or crossing guard determines that it is safe for you to do so.' However, rules may not be understood or remembered when needed. For example, young children may interpret literally the statement 'cross only with an adult or a crossing guard present', concluding that the presence of a crossing guard is sufficient for them to cross the street, even if his back is turned. Rules must be stated in a way that the child can comprehend through speech or reading. Negative and passive sentences are difficult for children less than 8 years to understand. Even 'left' and 'right' may be confused in traffic situations until about age 9.³⁵ In an evaluation of the popular six line British Green Cross Code, 20% of children tested misread or did not read at all,⁶⁷ or did not heed⁶⁸ the rules, which were written at grade 3-4 Flesch-Kincaid reading level (about the same as a Hemingway short story).⁶⁹ Even if these rules were understood,

they only cover rudimentary crossing skills, not those of complex traffic.

Another problem is the inflexibility with which young children (generally before age 10), follow rules. This could endanger children faced with a new traffic situation. When an inflexible view of rules is combined with the normal egocentric view of young children, a child may 'logically' conclude that walking in a pedestrian crossing zone renders him magically safe from all harm. For example, children 5-6 years old taught the Green Cross Code did not know its purpose, but would repeat the words when crossing as a talisman to ward off cars.⁷⁰

Classroom posters and other printed material are often used in pedestrian education. However, the limited attention of young children, combined with their difficulty in selecting relevant cues, suggests that the effectiveness of such materials may be limited. In one study, less than 10% of children could remember the content of the poster, and after a single lesson, only about one fourth of children 7 years or younger could recall the safety points illustrated.⁷¹ In another study, classroom teaching using a table top model was not substantially effective.⁷² Audiovisual aids may not be very effective either; one research team observed no pre/post difference in stopping behavior after a film was shown to children in grades 4-6.⁷³ Finally, several studies indicate that, although classroom education may improve knowledge of pedestrian safety issues, it does not change children's behavior.^{74,75} The poor ability of young children to generalize from the classroom to the street, or their inability to think abstractly, further limits the potential success of classroom teaching.

Studies of simulated traffic, such as traffic gardens or safety towns, note a general lack of effectiveness.⁷⁶ The method may be superior to classroom education for some, but not for other children. In one study, no long range benefit was demonstrated.⁷⁷

Some data suggest that some children can achieve better road crossing skills with specialized, practical training using real traffic situations.⁷⁸ One such method used was a pretend road, a stretch of pavement located parallel and adjacent to a real road but protected from it by a barrier. Several studies suggest that, using a pretend road, elementary school children can be taught to judge gaps at nearly adult levels.⁷⁹ For example, the mechanics and purpose of a two way pretend road was taught to 5 year old children, who then used it to achieve roadway crossing competence at a level similar to that of older children.⁸⁰

Conclusions

Pedestrian safety is a complex problem. For a young child, the act of crossing a street is a conscious, problem solving situation, with each circumstance appearing to be unique. Is a child ready and able to acquire the necessary skills through education or training, or should these approaches be made secondary to efforts designed to change driver behavior, adult supervision, or the roadway environment? It

appears that certain elements can be taught successfully, albeit with great educational effort; the pretend road is a good example of this. The question still remains, should pedestrian safety be a primary focus of injury prevention education?

Several factors should be considered in answering this question. First, statistical comparisons between intervention and control groups generally do not take into account the *absolute level* of performance achieved, which is critical. Two examples demonstrate this well. A study of roadway crossing techniques in 5 year olds noted that table top education resulted in improvements that were statistically equal to those of real traffic education, but the performance level achieved by the groups using the two methods was poor. At best, only 44% of either group chose a 'safe' or 'more safe' method of crossing.⁸¹ Another study noted that young children improved their crossing ability at intersections, so that nearly 75% performed in a safe (albeit minimally so) manner after instruction, compared with less than 20% of the control group. Again, is this proportion high enough for safety?⁸² Because the momentum of a motor vehicle weighing 1000 kg and travelling at 50 kph is one thousand times greater than that of a young child weighing 10 kg and traveling at 5 kph, any collision can result in a serious or fatal injury. Accordingly, collisions must be stringently avoided. An improvement in outcome from education or any other countermeasure is insufficient if it leaves one in four children at risk, even if it is statistically significant.

Second, outcome studies thus far have not determined whether children behave the same under supervised test conditions as they would when observed unobtrusively. For example, pretend roads seem to be a promising method of training young children to cross even two way streets successfully. However, does this permanently increase their vigilance and reduce their normal lapses in attention? This requires further investigation.

A developmental perspective suggests that traditional pedestrian traffic education has limited value for young elementary schoolchildren, and that most efforts targeting this age group should be directed towards improving the roadway, vehicles, drivers, and adult supervision. However, this does not preclude the importance of educating or training the child. As noted, pedestrian injury has many causes, and child behavior may be amenable to education and training. Those behavioral aspects amenable to improvement are worth tackling, but, to be useful, the education and training provided must be based on the child's developmental stage and consequent ability to comprehend and incorporate such information.

Meanwhile, developmental experts, especially educational psychologists and behavioral scientists, should be encouraged to participate in developing new techniques that might improve pedestrian behavior of young children. For example, virtual reality computer programs could be developed to allow repetitious, individualized, staged instruction of dealing

with traffic threats using a personal computer. They also should be encouraged to conduct more observational studies of real life crossing patterns of children at various ages, cultures, and urban and rural settings, to determine the social norm of young children walking to and from school and at play. This might indicate circumstances where an adult, rather than an older sibling, needs to supervise the young child. Because very young children cannot be taught effectively how to deal with traffic, urban planners and traffic engineers should be encouraged to develop safer residential communities by restricting vehicular access and slowing traffic, and to discourage playing in the street by introducing safe playgrounds.⁸³

Adult supervision, however, remains a principal solution for young children. Parents and child safety advocates should promote better parent assessment of children's capabilities, and more adult supervision of child pedestrian behavior, during the grade school years.⁸⁴ This is particularly important because the ages at greatest risk coincide with the period when parents are most likely to overestimate their children's pedestrian skills.⁸⁵ All such efforts should be undertaken with developmental characteristics of children in mind. The age at which adults should permit children to cross the road independently is related to many factors, including especially the type of roadway, traffic density, visibility of children at the roadside, and their developmental stage. The parent should not assume that, because a child can cross some streets under some conditions, that he or she is ready for independent (unsupervised) walking. Instead, the parent should either ensure adult supervision, or establish rules to indicate which path(s) the child may take on commonly traveled routes and which streets may be crossed independently. In our opinion, as a rough guide, daytime crossing of low traffic residential streets familiar to the child should be supervised until about age 7 or 8. Busy streets with several traffic lanes and a signalized crosswalk could be negotiated independently by most children at about 12 years. Road crossing of major arteries should be supervised until adolescence.

In summary, the child's developmental stage dictates how he or she views and responds to vehicular traffic. Pedestrian training and education must fit the fundamental framework of the child's thinking to be effective. Because certain aspects of training are not within the reach of toddlers and preschool children, environmental countermeasures and adult supervision must be relied upon. Awareness of the stages of child development and their impact on pedestrian skills should help parents, educators, and injury prevention experts protect child pedestrians better.

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DWI charges and severity of injury

A study abstracted in *Inroads* — the Quarterly Bulletin of the AAAM (winter 1996) and originally published in the *Annals of Emergency Medicine* (1996; 27: 66-72) concludes that injured alcohol-impaired drivers who require at least emergency treatment are infrequently charged with DWI, and that, the more severe the injury, the less likely a DWI charge.

Not drunk?

A driver in Montreal who ran a red light, killing one passenger in another car and severely injuring another, claimed not to be drunk. He refused a blood sample, claiming he had 'felt hot and then blacked out' thus causing the 'accident'.

Passing strange

I admit, it seems strange for a journal editor to be excerpting material from another's abstracts, but Jan Shield's *Child Safety News* is so good it is hard to resist. In the March 1996 issue, she includes a paper called 'Making reading easier' which I urge all our authors to read and take to heart (*Archives of Disease in Childhood* 1996; 74: 180-2). As well, I was struck by the wide range of 'mainstream' journals publishing child injury papers: the *BMJ*, *Developmental and Behavioral Pediatrics*, *Pediatrics*, *Archives of Pediatrics and Adolescent Medicine*, *JAMA*, the *Medical Journal of Australia*, to name but a few. Equally important are the smaller journals that also need to be considered: *Children's Environments*, *Journal of Trauma*, *Pediatric Annals*, *Journal of Burn Care and Rehabilitation*, *Annals of Emergency Medicine*, *Journal of Public Health Medicine*; these are but a few examples.