

Deana is my daughter. She was 17 years old when her life was cut short. Deana was with four friends going to a birthday party. They had just got out of a taxi and were trying to cross the Nile Corniche in Maadi. The traffic is heavy, chaotic. There are no traffic lights, no crosswalks, just a constant stream of speeding, weaving cars, trucks and buses. You have to dart across several lanes of traffic to get to the other side. Deana was hit and killed by a speeding bus as she tried to cross the road. The bus driver didn't even slow down.

I was in Damascus at the time, travelling for my work. My brother-in-law called me to tell me the terrible news that my baby girl had been hit. You can imagine my guilt. I should have been in Cairo. I could have driven her to the party.

Deana loved so many things, she loved life. She had an infectious smile. She always had time for other people more than for herself. She wanted to be a paediatric dentist – she loved kids. She had a special love of angels. She always had pictures or figurines of angels in her room. For us, she has become the “Angel of the Nile”.

Everyone was deeply affected by Deana's death, her family her friends, the entire community. I think of ripples of pain, an ever-widening circle of those who were affected. My wife, son and I had to leave Cairo after Deana's death. It was too painful, too many memories. We came back to Cairo just a few months ago.

I guess that early on I made a decision. I could roll up into a ball in a foetal position and never wake up. It would be very easy to do this and give up. But I felt that I had tried to make sense out of the senseless, the unbelievable. I decided to do something tangible, something that would save other people's lives.

An NGO, the Safe Road Society, started because our daughter lost her life. It is dedicated to making the roads in Egypt safer for its citizens. Our first project is the building of a pedestrian tunnel under the Maadi Corniche El Nile. Governmental permits have been obtained and request for construction bids sent. Our next step

is to ensure sufficient funds are raised through voluntary donations to complete this life saving project. This busy road of death runs alongside the serenity of the Nile River. Many concerned and dedicated Egyptians and foreigners have joined together with the goal to make the tunnel a reality. Also, a scholarship was started in Deana's name at her school and every year a graduating senior who smiles and brings light to another student's day is awarded a helping hand.

By building a pedestrian tunnel we hope to save lives and, in my dreams, to see my Deana, my Angel of the Nile, looking down upon us and smiling in approval.



Chapter 2

Road traffic injuries

Introduction

In many places the road network is constructed without considering children. Children, though, use the roads as pedestrians, bicyclists, motorcyclists and occupants of vehicles. They may live close to a road, play on a road, or even work on the roads. All these interactions with roads, together with a range of other risk factors associated with childhood, increase the susceptibility of children to road traffic injury.

This chapter examines the extent and characteristics of road traffic injuries for different types of road users among children aged 0–17 years, as well as their risk factors. Proven and promising interventions, for the different types of road user, are discussed, along with their effectiveness and cost-effectiveness. The chapter concludes with some recommendations for preventing the growing toll of road traffic injury.

For the purpose of this report, a road traffic crash is defined as “a collision or incident that may or may not lead to injury, occurring on a public road and involving at least one moving vehicle”. Road traffic injuries are defined as “fatal or non-fatal injuries incurred as a result of a road traffic crash” (1). Although other definitions exist, a road traffic fatality is considered to be a death occurring within 30 days of a road traffic crash (2).

This chapter focuses on children aged 0–17 years. Comprehensive data, however, are not always available across the whole age range. In particular, information is often limited for children aged between 15 and 17 years. There are also problems of under-reporting of road traffic deaths and injuries, particularly in low-income and middle-income countries, limitations that need to be taken into account when interpreting the data.

The road is a dangerous place for children and young people. However, road traffic injuries do not have to be the price children and their families pay for the increasing mobility and independence of children as they grow up. There are proven and effective measures that can be put into place to reduce their risks to a minimum.

Epidemiology of road traffic injuries

According to the WHO Global Burden of Disease project, in 2004 nearly 1.3 million people of all ages were killed in road traffic crashes around the world and up to 50 million more were injured or disabled. The South-East Asia and the Western Pacific Regions of WHO together accounted for two thirds of all road traffic deaths. However, the highest rates of road traffic death were in the African and

Eastern Mediterranean Regions. Globally, 21% of road traffic deaths were among children.

There have been downward trends in the numbers of road traffic deaths and injuries over the last couple of decades in several developed countries. Globally, though, the outlook is disturbing. By the year 2030, road traffic injuries are predicted to be the fifth leading cause of death worldwide (3) and the seventh leading cause of disability-adjusted life years lost (4). The South-East Asia, African and Western Pacific regions are expected to see the most significant increases in road traffic injuries. Of particular concern is the fact that in India and China – each with more than a sixth of the world’s population – the number of road traffic deaths is predicted to increase, by 2020, by approximately 147% and 97%, respectively (5).

Mortality

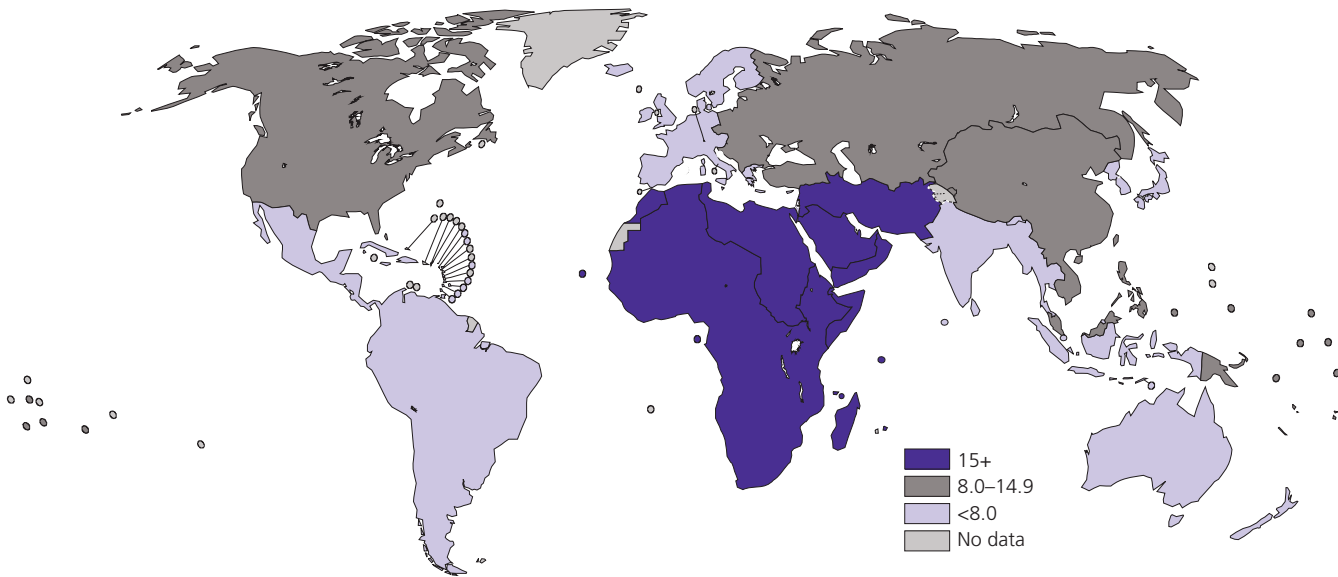
In 2004, road traffic injuries accounted for approximately 262 000 child deaths among children and youth aged 0–19 years – almost 30% of all injury deaths among children (see Statistical Annex, Table A.1). Road traffic injuries are the leading cause of death among young people aged 15 to 19 years (see Table 1.1). Globally, these deaths on the roads account for nearly 2% of all deaths among children. There are significant geographic variations, however. In the South-East Asia Region, the proportion of childhood deaths due to road traffic injuries is 1.3%, while in the Americas it is as high as 4.7%. Some 93% of child road deaths occur in low-income and middle-income countries (see Statistical Annex, Table A.1). In 2004, the South-East Asia and African Regions and the low-income and middle-income countries of the Western Pacific Region accounted for two thirds of all road traffic deaths among children.

Data shows that globally, the road traffic death rate among children is 10.7 per 100 000 population (see Figure 2.1). In South-East Asia, however, the rate is 7.4 per 100 000 population, while in the African Region it is 19.9 per 100 000 population. Although the mortality rate is not as high in Europe, road traffic injuries still account for around a fifth of all childhood *injury* deaths across the European Union (6).

In addition to regional differences, there are also variations according to the type of road user. In 70 countries – mainly middle-income and high-income countries – that provide sufficiently detailed mortality data to WHO, about 33% of all child deaths around the world are pedestrians, while 65% are car occupants or bicycle or motorcycle riders (7).

FIGURE 2.1

Road-traffic injury mortality rates per 100 000 children^a by WHO region and country income level, 2004



Africa		Americas		South-East Asia	Europe		Eastern Mediterranean		Western Pacific	
LMIC	HIC	LMIC	HIC	LMIC	HIC	LMIC	HIC	LMIC	HIC	LMIC
19.9	8.7	7.7		7.4	5.2	8.3	18.3	17.4	4.2	8.6

^a These data refer to those under 20 years of age.

HIC = High-income countries; LMIC = low-income and middle-income countries.

Source: WHO (2008), Global Burden of Disease: 2004 update.

Age

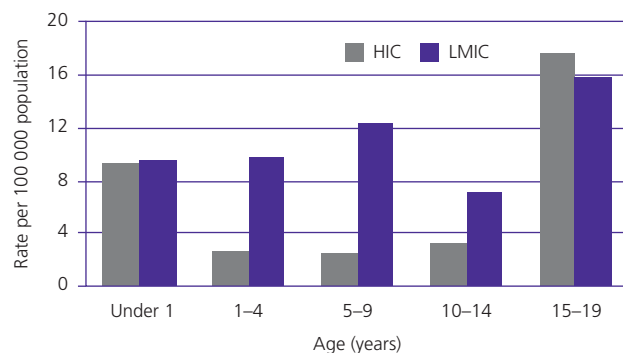
Globally, road traffic injuries are the leading cause of death among 15–19-year-olds and the second leading cause among 5–14-year-olds (see Table 1.1). Global road traffic fatality rates increase with age (see Figure 2.2), reflecting the way children of different ages use the road. Children up to the age of nine years are more likely to be accompanied by parents when they travel, either in vehicles or as pedestrians, while older children tend to travel more independently, initially as pedestrians and later as bicyclists, motorcyclists and finally drivers. The higher rates of injury among children aged 10 years and over is a result of this increased mobility as well as of their increased tendency to exhibit risk-taking behaviours.

For all age groups, except for the 15–19-year age group, road traffic fatality rates are greater in low-income and middle-income countries than they are in high-income countries.

Surveys in five Asian countries showed that road traffic injuries are the second leading cause of child mortality (see Statistical Annex, Table B.1). In Bangladesh, for instance, road traffic injuries were the second most common cause of injury deaths in children aged 1–9 years, whereas in children aged 10–14 years they were the leading cause, accounting for 38% of all child deaths. In those aged 15–17 years, road traffic injuries accounted for 14% of injury

FIGURE 2.2

Fatal road-traffic injury rates per 100 000 children by age and country income level, World, 2004



HIC = High-income countries; LMIC = low-income and middle-income countries.

Source: WHO (2008), Global Burden of Disease: 2004 update.

deaths (8). In Thailand, 40% of injury deaths in 10–14-year-olds were from road traffic injuries (9).

Gender

From a young age, boys are more likely to be involved in road traffic crashes than girls. The difference in incidence rates between boys and girls increases with age until children reach 18 or 19 years of age, when the gender gap

is similar to that seen in adulthood (see Table 2.1). Overall, the death rate for boys is 13.8 per 100 000 population, compared to a rate for girls of 7.5 per 100 000 population. In the high-income countries of the Eastern Mediterranean Region the gender gap is greatest among young children while in the regions of Europe, the Western Pacific and the Americas the gap is more pronounced among older children (see Statistical Annex, Table A.1).

TABLE 2.1
Fatal road-traffic injury rates per 100 000 children by age and sex, World, 2004

	Age ranges (in years)					
	Under 1	1–4	5–9	10–14	15–19	Under 20
Boys	11.5	9.7	13.3	8.7	23.4	13.8
Girls	7.4	8.3	9.3	4.5	7.9	7.5

Source: WHO (2008), Global Burden of Disease: 2004 update.

Morbidity

The number of children injured or disabled each year as a result of road traffic crashes is not precisely known, but has been estimated at around 10 million. This figure is based on data from health-care institutions that suggest that children make up between a fifth and a quarter of those involved in a road traffic crash and admitted to a hospital (10–12). However, community-based surveys from Asia suggest that the figure could be much higher. The surveys found that, for every child who died as a result of a traffic injury, 254 presented to a hospital facility with injuries, four of whom were left with permanent disabilities (13).

In children under the age of 15 years, road traffic injuries rank as the eleventh cause of death and the tenth cause of burden of disease among children (see Statistical Annex, Table A.2). Globally, road traffic injuries among this age group account for 9482 disability-adjusted life years lost – 1.7% of the total disability-adjusted life years lost.

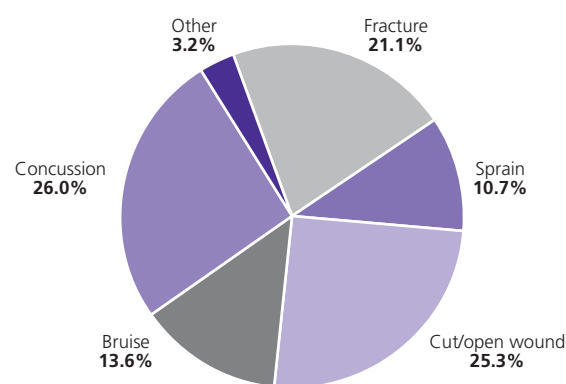
In general, there is a lack of data on morbidity, particularly from low-income and middle-income countries. This is partly because not all children injured in road traffic incidents are taken to hospital and partly as a result of poor data collection systems.

Nature and severity of road traffic injuries

The head and limbs are the most common parts of the body injured in children involved in road traffic crashes. The severity of injuries will vary, depending on the age of the child, the type of road user and whether protective devices were used. A recent school-based survey conducted by WHO looked at 13–15-year-olds in 26 countries. Of those children reporting an injury involving a motor vehicle in the previous 12 months, 10% had sustained a minor head injury and 37% had fractured a limb.

These survey results are supported by a hospital-based study of injured children under the age of 12 years, conducted in four low-income countries. The study found that, among those suffering road traffic injuries, more than a quarter had incurred a concussion or other head injury, followed by various cuts, bruises, open wounds, fractures and sprains (see Statistical Annex, Table C.1 and Figure 2.3).

FIGURE 2.3
Injuries sustained by children^a presenting to an emergency department as a result of a road traffic crash in four countries^b in 2007



^a Children were under 12 years.

^b The four countries were Bangladesh, Colombia, Egypt and Pakistan.

Source: Statistical Annex, Table C.1.

Chest and abdominal injuries, although not as common as head and limb injuries, can be very serious because of the organs involved and the difficulties in managing such injuries. Multiple trauma has also been reported in approximately 10% to 20% of children involved in road traffic crashes (14).

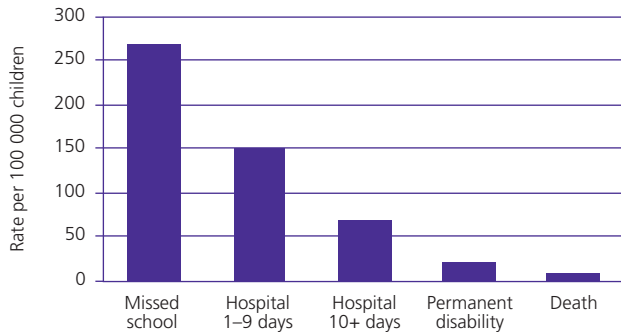
Consequences of road traffic injuries

Road traffic injuries are a leading cause of disability for children. Recent surveys in Asia show that road traffic injuries are one of the five leading causes of disability for children. The exact proportion of children disabled by road traffic injuries varies by age group and across countries (15). According to these surveys, the rate of permanent disability among children aged 1 to 17 years injured as a result of a road traffic crash was 20 per 100 000 children. In addition, significant numbers of children required hospitalization or missed school as a result of their injuries (see Figure 2.4).

Studies conducted among both adults and children highlight the fact that many individuals still retain some functional disability 6 to 12 months following a road traffic crash. Clearly, the type of injury sustained affects the period needed for complete recovery. Research in Bangalore, India, for instance, found that 14% of children who sustained a traumatic brain injury from a road traffic

FIGURE 2.4

Severity of road traffic injuries per 100 000 population among children aged 0–17 years, in five Asian countries^a



^a Bangladesh, China (Beijing, Jiangxi province), Philippines, Thailand, Viet Nam.

Source: Reference 15.

crash still required assistance with day-to-day activities six months after the crash (16).

The outcome of a road traffic injury is also related to road user type. One study found that 72% of pedestrians, 64% of bicyclists struck by a car, and 59% of child vehicle occupants required assistance six months after a crash (17). In Canada, 22% of bicyclists injured without a motor vehicle being involved in the incident required subsequent assistance (18).

Disabilities and impairments impede the progress of children in their early years depriving them of education and social development. Children who sustain disabilities following a road traffic crash frequently require long-term care and their quality of life is often poor. The excessive strain placed on families who have to care for their injured children may result in adults having to leave their jobs, leading to conditions of poverty.

Psychosocial impact

A number of mental health conditions have been observed in children following a road traffic crash. These include phobias, post-traumatic stress disorder and anxiety, as well as behavioural problems. These psychosocial disturbances may be exacerbated by family impoverishment following a road traffic crash, particularly if a parent or caregiver was also involved in the collision and was severely injured or died. Injured children can thus experience high levels of psychosocial distress (19) and feel isolated in their suffering (20).

Several studies have reported high levels of distress in children during and immediately after a road traffic injury (17, 21, 22). One study reported that that within five days of a traumatic event, such as a road traffic crash, 98% of the children involved suffered post-traumatic stress disorder, depression or anxiety. One month after injury, 82% still had symptoms. Twelve months after injury, 44% were still having flashbacks, feared being injured again, or suffered mood disorders, body-image changes, sleep disturbances

or anxiety (23). Another study found that a quarter of children were exhibiting post-traumatic stress disorder three months after the crash (22).

Road traffic crashes can also have a profound psychological effort on children not directly involved in the incident themselves but who lose a parent or caregiver (see Box 2.1). Results from Asia show that among orphans, 20% to 66% have lost a father, mother or both in road traffic crashes (15). The loss of a parent or parents can leave a child with long-term psychosocial problems as well as economic impoverishment.

Types of road user

Children suffer injuries while in a variety of roles related to different types of transport. They may be pedestrians, bicyclists, car occupants, motorcycle riders or motorcycle passengers, or passengers on public transport. In some countries, children work on the streets, usually selling merchandise, where they weave in and out of moving traffic.

BOX 2.1

Children orphaned through road traffic deaths

The Bangladesh Health and Injury Survey, a population-based survey of 171 366 households, was conducted in 2003. A verbal autopsy module was used, adapted from the WHO standards for verbal autopsy (24), with specific questions on each type of injury. Data were analysed for the causes of death of parents of children aged 0 to 17 years.

Injury was a leading cause of death of parents of children under the age of 18 years. Some 4 300 mothers die from injuries in Bangladesh each year, leaving about 17 700 children without their primary caregiver. As shown in the table below, the leading cause of injury death for mothers is suicide (41%), followed by road traffic crashes (29%), burns (12%) and violence (10%).

CAUSES OF INJURY-RELATED DEATHS AMONG PARENTS OF CHILDREN AGED 0–17 YEARS

	Causes of all injury deaths (%)					
	Suicide	Road traffic injuries	Burns	Violence	Falls	Other
Mothers	41	29	12	10	3	5
Fathers	12	36	0	27	5	13

Source: Reference 8.

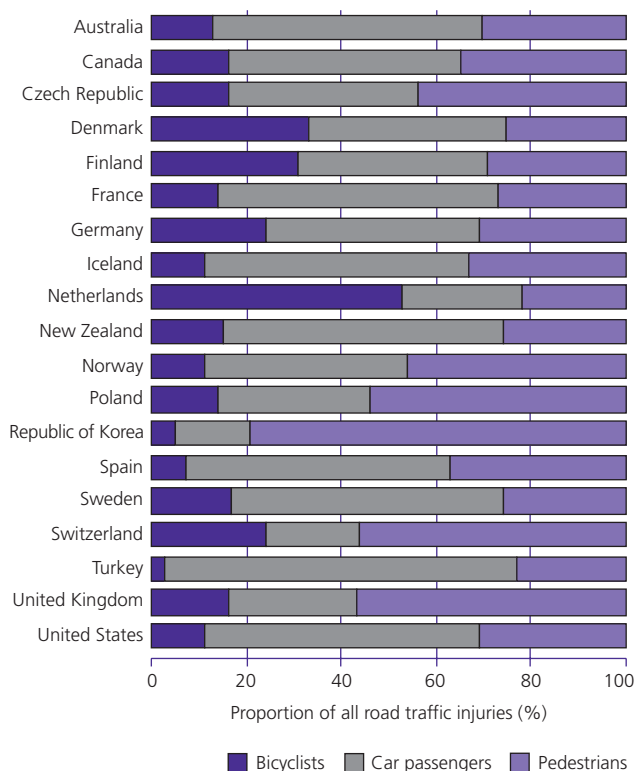
Around 7 900 fathers die from injury annually, leaving nearly 22 100 children in households that have lost their primary wage earner. The most common causes of injury death in fathers are road traffic crashes (36%), followed by violence (27%) and suicide (12%).

Children deprived of one or both parents are vulnerable to malnutrition, illness, impaired development, psychosocial trauma, exploitation and abuse. In Bangladesh, as in many countries, fatal injuries of parents are a significant cause of orphaning. This damages the children left behind and is a huge burden on society. As well as preventing injuries among children, societies need to take greater steps to reduce the incidence of injuries, both unintentional and intentional, among adults.

The patterns of road use among children vary by country, affecting the type of injuries they sustain (see Figure 2.5).

FIGURE 2.5

Proportion of fatal road traffic deaths among children^a by type of road user in selected OECD countries



^a These data refer to children under the age of 15 years.

OECD = Organisation for Economic Co-operation and Development.

Source: Reference 25, reproduced with permission.

Pedestrians

Globally, pedestrians form the single largest category of children involved in road traffic crashes. In high-income countries between 5% and 10% of children suffering road traffic injuries are pedestrians, while in low-income and middle-income countries the proportion ranges from 30% to 40% (26). Child pedestrian injury is highest in Africa and Asia where it is usual for people to walk along roads (12, 15). Despite significant reductions in child pedestrian injury in many high-income countries, the prevention of such injury remains a problem, particularly among 5–14-year-olds.

Occupants

Children injured or killed while travelling in cars as occupants are a serious concern in high-income countries, where such cases can account for up to 50% of childhood traffic deaths (27). As motorization increases, child occupant deaths are also an emerging problem in many middle-income countries.

Bicyclists

In many countries, children are taught to ride bicycles as a form of recreation. In many parts of Asia, bicycles are also a common means of transport. This is reflected in the statistics. Bicyclists constitute 3%–15% of children injured in traffic collisions and 2%–8% of child traffic-related fatalities around the world (26). In some Asian countries, though, the latter figure can be as high as 33% (28). While there has been a decline in bicyclist deaths among children in high-income countries (27), bicycle-related injuries are increasing in many low-income and middle-income countries, particularly in South-East Asia and the Western Pacific (28).

Motorcyclists

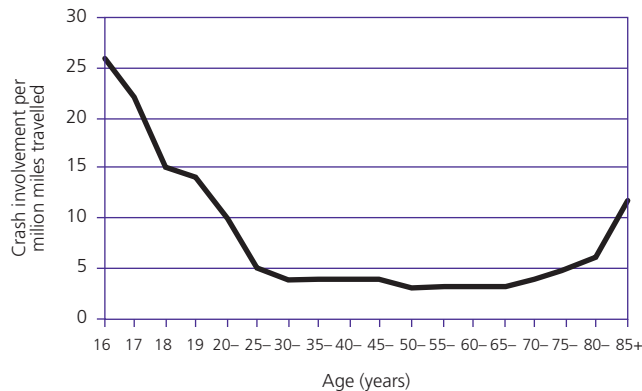
Where motorcycles are commonly family vehicles, children may begin to travel on motorcycles at an early age, either sitting on the petrol tank or behind the driver. In some Asian countries, where motorized two-wheelers are the most common form of transportation and children are legally allowed to drive small-engine motorcycles from their 15th year, motorcycle crashes are the leading cause of mortality and morbidity among teenagers (15).

Young drivers

Injuries and fatalities among young drivers are a major problem in high-income countries, where a large study showed that crashes involving young drivers accounted for between 20% and 30% of all road traffic fatalities (29). In particular, young drivers are at high risk of a crash in their first year of driving by themselves. Research from Sweden shows that novice drivers are 33 times more likely to have a crash than other drivers (30), while in Western Australia, drivers on a provisional licence are 15 times more likely than older drivers to be involved in a crash (31). In the United States, the risk of a crash for a driver aged 16 years is five times the average risk for all ages (32) (see Figure 2.6). Although mortality rates among young drivers have decreased in most high-income countries in recent decades, the relative proportion of young drivers among all drivers killed remains high, confirming that greater prevention efforts are required among this category of road user.

Heavy vehicles

Only a few studies have specifically examined the risk to children involved in heavy vehicle crashes (33). Public transport vehicles for children are primarily buses, heavy vehicles and school transport vehicles. Unsafe buses in low-income and middle-income countries are frequently involved in major crashes involving children. In high-income countries, the greatest risk to school children is while alighting from a bus – rather than from a crash involving a school bus (34, 35).

FIGURE 2.6**Driver crash involvement per million miles^a travelled by driver age, United States, 2001–2002**

^a 1 mile is approximately 1.60934 kilometres.

Source: Reference 32, reproduced with permission.

Economic impact of road traffic injuries

The global losses due to road traffic injuries are estimated to be US\$518 billion per annum (36), with the annual cost of road crashes in low-income and middle-income countries estimated at between US\$65 billion and US\$100 billion. This means that road traffic collisions and their consequences cost governments up to 3% of their gross national product (1). Information on the global cost of road traffic injuries exclusively among children is not available.

The direct and indirect costs of road traffic injuries, both for those directly involved and for national economies, are numerous. The direct and indirect costs include:

- permanent disabilities;
- loss of schooling;
- medical care;
- legal costs;
- vehicle repair costs;
- loss of income to parents, resulting from absence from work to care for the child.

In addition, there are long-term economic costs arising from: premature death; rehabilitation; the loss of healthy years in children; and the inability of those with serious disabilities to work to the full extent.

The poor, who are over-represented in road traffic crash statistics, are hardest hit by these costs. Findings from research in Bangladesh and India suggest that there is a further decline into poverty when the poor are injured. This is because additional resources are needed to care for the injured person, achieved by taking on extra work, selling assets or taking out further loans (37).

Limitations of data

Many countries do not have injury surveillance systems that provide reliable data on road traffic crashes and injuries. Indicators, particularly on non-fatal outcomes,

are scarce and those that are used suffer from a lack of standard definition – particularly as regards what is meant by minor, moderate or severe injuries. There are frequent disparities between data – for example, between police and health-related sources – making comparisons difficult (1). These difficulties are made worse by the fact that there is widespread under-reporting of road traffic fatalities and injuries – both in health-related and police data.

In addition to these limitations, there is an additional problem of different age cut-off points when dealing with child-related road traffic injuries and deaths. This makes comparisons particularly difficult.

Solid data are needed to provide a basis for decision-making. Establishing a simple, cost-effective system or improving systems currently in use should be priorities in improving road safety. All the same, a current lack of reliable data should not prevent other necessary measures from being undertaken.

Risk factors

Most of the factors that increase the risk of road traffic injuries for the general population do so similarly for children. Thus children are affected by speeding and drink-driving, by not using safety equipment and by factors related to vehicle safety and the road environment. However, there are also risk factors that are specific to children. The road environment is constructed with consideration for adults. It is not built for use by children, and when children come into contact with it they are placed at greater risk than need have been the case. The set of risk factors that increase a child's susceptibility in road traffic can be considered within the conceptual framework of the Haddon Matrix (see Table 2.2).

Child-related factors

Physical development

A child's head, chest, abdomen and limbs are all in a state of growth. Their relative softness make a child physically more vulnerable to the impact of injury than an adult. Furthermore, the smaller physical stature of children can create problems, as it limits their ability to see or be seen over certain heights such as parked cars or large trucks – a known risk factor in child pedestrian injuries. Children's sensory facilities are also less fully developed. Their ability to synthesize information, from their peripheral fields of vision and their auditory sense, is limited, which can lead to their missing critical cues of danger, thus increasing their risk of road traffic injury (38).

Cognitive development

The developmental processes taking place in children have an effect on their ability to make safe decisions in the road environment, and these processes are closely related to age (39).

TABLE 2.2

Haddon Matrix applied to the risk factors for road traffic crash injuries among children

	Child factors	Vehicle and safety equipment	Physical environment	Socioeconomic environment
Pre-event	Age; gender; lack of supervision; risk-taking; impulsive behaviour; disobedience; lack of police enforcement.	Lack of roadworthiness of vehicle; poor lighting; poor state of brakes; speeding; overloading.	Poor road design; lack of public transport; no enforcement of speed limits; no safety barriers; lack of alcohol laws; poor infrastructure for pedestrian safety.	Poverty; single-parent family; large family size; poor maternal education; lack of awareness of risks among caregivers, childcare providers and educators.
Event	Size and physical development of child; lack of equipment to protect occupants, or equipment improperly used; underlying conditions in child.	Child restraints and seat-belts not fitted or incorrectly used; bicycle and motorcycle helmets not used; poor design of vehicle for protection in crashes; no rollover protection.	Roadside objects such as trees and poles.	Lack of safety culture in the car and on the road.
Post-event	Child's lack of resilience; child's general condition; lack of access to appropriate health care; post-injury complications.	Difficult access to victim; lack of trained health-care and rescue workers.	Lack of availability of adequate pre-hospital care, acute care and rehabilitation.	Lack of culture of supporting injured people; no first aid given at scene.

Young children aged between five and seven years have mastered the concepts of speed and distance (40). However, they exhibit poor skills in recognizing dangerous places to cross the road, relying exclusively on the visible presence of cars in the vicinity. They are also unlikely to assess the presence of oncoming traffic with accuracy. “Blind” sections of the road, obstacles by the road that could obscure a child from a driver’s field of vision and complex road junctions are not perceived by young children as threatening situations (39, 41). Road traffic crashes involving young children include a large proportion of “dart and dash” cases. In such cases, a child pedestrian is injured through a “critical behavioural error”, where it has failed to stop or slow down before attempting to cross the road. This type of behaviour is due to a child’s “centration” – the inability of the child to switch attention from one task to another (42).

These cognitive processes are more developed in children aged 11 years and older who appear to be able to recognize a given road location as dangerous and show judgement that allows them to be safe on the roads (43). Children over the age of 12 years have the capacity to modify their behaviour when faced with a situation involving two tasks.

This is an area of ongoing research and new evidence relating to children’s abilities on the road is regularly published. Two issues have recently arisen in this connection, both related to cognitive development.

- There is growing evidence that, although the visual processes needed for a child to cross a road are fully developed as infants, the full integration of visual signals into a meaningful context is not fully developed until children are around 10–12 years old (44, 45).
- Cognitive processes taking place in an adolescent’s brain could affect their risk of road traffic crash as

young drivers. Through the use of brain-imaging techniques, neurobiological research conducted over the past decade has found that parts of the frontal lobe – in particular the prefrontal cortex which governs judgement, decision-making, reasoning and impulse control – appears not to fully mature until the age of 20 or 25 years (46). While research linking this new evidence on brain development directly to driving has yet to be undertaken, these findings provide some insight into the biological mechanisms that may put many young drivers at risk.

Risk-taking behaviour

While young children may inadvertently take risks because they lack appropriate skills to do otherwise, older children and adolescents may actively seek out risk. Risk-taking behaviour may allow adolescents to feel a sense of control over their lives or else to oppose authority. Research shows that there are high levels of sensation-seeking behaviour among young adults and that there exists a need to maintain a heightened level of physiological arousal. Young people consequently seek new situations and experiences to maintain this level, irrespective of the risks inherent in the experience. Such sensation-seeking frequently focuses on risky behaviours, including while driving a vehicle or crossing a road. Sensation-seeking has been shown to rise between the ages 9 and 14 years, peaking in late adolescence or in early adulthood, and declining steadily with age (47).

Risk-seeking behaviour is a significant predictor of involvement in road traffic injury among child pedestrians as it is for young adolescent drivers aged 16–17 years (48–50). Across all ages and particularly among the young, sensation-seeking is more common among boys than among girls. Boys as young as 11 years have a greater

affinity for speed, risk-taking and competitive behaviour, all of which place them at an increased risk of road traffic injury (51).

A certain amount of risk-taking is a normal physiological attribute and is necessary for a child's growth and development. Children, though, often do not realize that they need to make a complex set of decisions to avoid harm. It is the responsibility of adults to understand the vulnerability of children in the road environment and their developmental limitations, and to ensure their safety by providing developmentally appropriate behavioural interventions.

Peer influence

As young children become adolescents, they enter a phase where the influence of their parents is reduced, and they begin to discover and assert their independence. This transition can be expressed in their lifestyle, and in an increasing conformity with certain social norms, that in turn influence their behaviour and decision-making. For many young people, peers are of significant importance and can be the primary source of the social norms with which they strive to conform (29).

Social norms, including peer pressure and the emphasis placed on rebellion in the culture of young people, can affect the manner in which young people drive a vehicle. Direct peer pressure may be exerted on the driver's behaviour through the influence of a passenger. Research has shown that young drivers experience higher peer pressure than older drivers to commit traffic violations such as speeding, driving under the influence of alcohol and dangerous overtaking (52). There is a close link between the presence of similarly aged passengers in the car and increasing risk levels. A number of studies have shown that young drivers, both male and female, drive faster and with a shorter following distance at road junctions if they have young passengers in the car (51, 53).

Gender

There is evidence of a strong relationship between gender, road safety behaviour and road traffic injury. Most studies conducted show a strong male bias, with the male-to-female ratio ranging between 3:1 and 5:1. This relationship holds true across different regions of the world and applies to fatal and non-fatal injuries.

A part of the predominance of boys in road traffic injury statistics can be accounted for by differences in exposure. Research on 10–12-year-old boy pedestrians has found that the amount of exposure, together with nature of the road environment, influences injury rates among this group, particularly those from poorer areas (54). However, exposure does not account for the entire difference. Among young drivers, men have more fatal crashes per kilometre driven than do young women, even taking into consideration their increased exposure levels. Factors

thought to contribute towards this difference include increased risk-taking and sensation-seeking.

Type of road user

There is no specific age at which children can be said to be safe road users. Children understand and react to complex traffic situations in different ways from adults. Younger children have different information-processing and psychomotor abilities compared to older children. Adolescents are characterized by impulsiveness, curiosity and experimentation. Developmentally, children develop at different rates and the differences between individuals can be large.

Pedestrians

In many parts of the world the majority of children injured or killed on the roads are pedestrians, particularly in low-income and middle income countries. The physical and cognitive developmental factors already discussed increase the risk of a road traffic crash among child pedestrians, especially among younger children, where physical stature and cognitive limitations restrict their ability to make safe decisions. In many low-income and middle-income countries children use roads for playing and for conducting small roadside businesses, both of which increase their exposure significantly. Risk-taking behaviour and peer pressure may increase risk among adolescents who are pedestrians.

Occupants

For young children who are occupants of vehicles the main risk factor is the lack or improper use of a restraint. Children should be strapped in appropriate restraints based on their age, weight or height (Box 2.2). The rate of use of appropriate child restraints in motor vehicles varies considerably across countries – from nearly 90% in the United States (55) to almost zero in Oman (56). While many parents use car seats for infants, the use of appropriate seat restraints decreases markedly after a child has outgrown the infant device.

Adolescents and young adults have the lowest wearing rates for seat-belts around the world. In a survey of youth risk behaviour, only a third of 14–17-year-olds reported that they always wore a seat-belt as a passenger in a vehicle. More than a third noted that they had been a passenger with a driver who had been drinking alcohol (60). In addition, having passengers of around the same age increases the likelihood of a novice driver, aged 16–18 years, incurring a crash (61).

Bicyclists

The major risk to bicyclists relates to exposure (62). In most high-income countries, children ride bicycles for pleasure and so make up a small proportion of road traffic deaths, though many minor bicycle collisions

BOX 2.2

How child restraints prevent injuries to child passengers

In the first half of the 20th century, traffic safety efforts concentrated on preventing crashes by changing the behaviour of drivers. In the 1950s, concepts already prevalent in aviation safety, including safety-belts, started to be applied to motor vehicles. Properly fitted seat-belts were found to absorb the energy caused by a rapid deceleration in a crash. In addition, a safety-belt reduced the risk of ejection from the vehicle and – if it fitted properly – spread the forces from a crash over hard bones rather than softer internal organs. The first laws came in 1966, when the United States federal government introduced regulations requiring new vehicles to be equipped with seat-belts.

European engineers recognized that biological differences between adults and children would limit the effectiveness of seat-belts for children. In the 1960s, they came up, for the first time, with a design specifically for children. This was a seat with child-sized internal harnesses attached to the vehicle frame by the vehicle's safety-belt. Various designs to accommodate growing children followed quickly. In 1963, the first rear-facing infant seat was developed.

Despite the commercial availability by the late 1960s of both seat-belts and child restraint systems, their safety benefits were not widely publicized and their use remained low. As countries became increasingly motorized, the numbers of deaths from crashes continued to rise. In 1970, the Australian state of Victoria introduced a safety-belt law and by 1977, rates of seat-belt use in the state had increased to 90%. Other countries gradually followed with their own seat-belt laws.

In the United States, in the late 1970s, studies found that infant deaths were over-represented among child passenger fatalities (57). The state of Tennessee, in 1978, was the first to adopt a child restraint law for all children under the age of four years. As a result, child restraint use increased from 8% to 30% and the incidence of deaths among child passengers was halved. By 1985, all of the United States and many other countries had introduced similar child restraint laws. Today, most of these laws have been amended to include requirements for the use of belt-positioning booster seats, that are effective in preventing injuries to children who have outgrown their child safety seats (58).

Ideas about how best to protect child passengers continue to evolve with new scientific findings and new technology. It is important, however, always to follow the current guidelines for the safety of child passengers (59). These guidelines urge that child restraint systems that have been certified as passing national standards should be used and that children should be placed in the rear seat. In rapidly motorizing countries, child deaths and injuries can be avoided through programmes and laws to promote child restraint use, through national standards to deliver the full benefits of the child restraint systems, and through a surveillance system to identify emerging hazards to children.



are never reported to the police (63). However, in many low-income and middle-income countries where cycling principally exists as a mode of transport, the proportion of road traffic deaths is considerably higher. In Beijing, for example, about a third of all traffic deaths are those of cyclists (28).

Other risks associated with bicycling include:

- the lack of correctly worn helmets (64);
- riding in mixed patterns of traffic (33);
- cycling on pavements (65);
- the visibility of cyclists (66).

The rate of helmet wearing among child cyclists is low in many countries, even in developed countries. A study conducted in South Africa in the late 1990s showed that only 1.4% of children presenting to an emergency department following a bicycle-related injury had worn a helmet at the time of the collision (67), although in those provinces where there were laws on helmet wearing, the rates were higher (68).

Motorcyclists

As with other types of road users, the greatest risk for children on motorcycles relates to exposure. In many countries children travel as passengers on a motorcycle from a very young age. The rates of helmet wearing among these small children is very low – partly as a result of the lack of appropriately sized helmets, or of their cost.

In many countries adolescents are legally entitled to drive a motorcycle with a restricted engine size from the age of 15 years. This age, though, coincides with a period in the child's development in which risk-taking behaviour is known to occur. Unsurprisingly, in some countries up to a third of all motorcycle deaths are young riders or their passengers (69). The use of helmets among motorcyclists and their passengers is low in many countries and is a significant risk factor for head injuries (70). In Viet Nam, for instance, helmet wearing rates among adolescent and young adult riders are generally lower than those among older adults (71).

Studies have shown that helmet wearing is highly dependent on the presence of a law mandating helmet use (60). The absence of universal helmet laws that cover all ages, together with poor enforcement and high prices for standard helmets, may contribute to the low prevalence of motorcycle helmet use in many places.

Young drivers

Adolescent and young drivers are a special risk group. A number of countries have reported increased collisions and deaths among novice drivers, particularly during their first year of driving (72–75). For a given distance driven, 16-year-old drivers are more than twice as likely as drivers aged 20–24 years, and four times as likely as drivers aged 25–29 years, to be involved in a fatal passenger vehicle crash (76). A number of interrelated factors appear to place young drivers at an elevated risk for road traffic injury.

- Age appears to be independent of the level of driving experience (29, 75, 77). Novice drivers aged 16–19 years have more crashes than novice drivers aged 20 years and over with the same amount of driving experience (77). However, there is a sharp decrease in crash risk during the first few years of driving, mainly associated with experience rather than age.
- Risky behaviours among young drivers include the following.
 - *Drinking and driving.* Alcohol significantly impairs driving ability among adolescents – typically at lower blood concentration levels than is the case for adults. New evidence suggests that the physiological response of adolescents to alcohol might be different to that of adults (78), making adolescents less sensitive to signals that their ability is impaired. Research in New Zealand found that drivers aged under 20 years were five times more likely to have elevated blood alcohol concentration levels compared with drivers aged 30 years and above (79, 80). In the United States, 30% of adolescents reported driving with an intoxicated driver in the previous month. One in 10 admitted to drinking and driving themselves (81).
 - *Speeding.* Adolescents are more likely to drive at excessive speed than are older adults (82). In a survey of 20 000 drivers aged 16 to 24 years, researchers found that the younger drivers were significantly more likely than the older ones to drive at more than 20 km/h above the speed limit (83).
 - *Non-use of seat-belts.* Compared with other age groups, adolescents have the lowest rate of seat-belt use. In 2005, 10% of high school students in the United States reported they rarely or never wore seat-belts when in a vehicle with someone else (81).
 - *Distraction.* Using a mobile phone, iPod or other electronic device, even if it is operated using hands-free devices, leads to slower information processing and consequently an increased risk of a crash (84).

The risk is even greater than that caused by the distraction of two or more passengers in the car (85).

- *Fatigue.* Adolescent drivers who lack adequate sleep are at greater risk of crashing. Fatigue can also exacerbate the effects of other risk factors such as alcohol, speed and inexperience (86–88).
- Young drivers of both sexes have a higher proportion of road traffic crashes in the evenings and early mornings. Many of these crashes involve only a single vehicle.
- The presence of other adolescents in the vehicle with an adolescent driver is one of the strongest predictors of a crash (73, 82, 89–91).
- There is a tendency among young drivers to violate traffic rules (92). A study in India found that 20% to 30% of traffic violations occurred among drivers less than 20 years of age, with more than a third of these drivers either unlicensed or having obtained a licence without taking a mandatory test (93).

Lack of supervision

Differences in parents' understanding of what activities are safe, given the particular age of the child, may partly explain the variations by age, gender and socioeconomic status in the patterns of road traffic injury among children across the world. The exact role, though, that a parent's perception of risk plays in determining the risk of a child incurring a road traffic injury is not clear. Attitudes to driving and road use appear to be formed at an age as early as 11 years, suggesting that a parent's perception of risk has the potential to influence a child's behaviour on the roads (51). However, there has been little research to date attempting to quantify the role that parental perception plays in a child's risk for road traffic injury.

Lack of adult supervision has often been cited as a risk factor among children for road traffic injury. However, it is just one of several interrelated risk factors. There are a number of characteristics associated with parents or caregivers with a limited ability to supervise children. These include being a single parent, being a working parent, and being a parent affected by illness or depression (94). Such characteristics are found in families across the world, and are fairly independent of the economic status of a country.

Nonetheless, if there is adult supervision, the probability of a child incurring road traffic injury is significantly reduced. A Malaysian study found that the risk of injury was reduced by 57% among children supervised by their parents (95). Another study, in Canada, found that lack of parental supervision increased the risk of injury to child pedestrians and cyclists by a factor of 2.6 (96). Research that examined the risk of child pedestrian injury in connection with specific supervision practices showed a strong positive association between pedestrian injury and a lack of supervision both after school and on the journey to school (97).

Poverty

The socioeconomic status of a family affects the likelihood of a child or young adult being killed or injured in a road traffic crash, with those children from poorer backgrounds at greater risk. This relationship is true not just between richer and poorer countries, but within countries as well. Data from both Sweden and the United Kingdom, for instance, show that the risks of children and young adults for road traffic injuries are higher if they are from poorer families (98–100). In Kenya, the choice of transport used is often related to a family's income – with those from low-income families more likely to be vulnerable road users (101). A study in Mexico found that family size was strongly associated with the risk of pedestrian injury among children (102).

Vehicle-related factors

Given the small stature of children, poor vehicle design is an important risk factor for child road traffic injury. The standard design of a vehicle can have a major effect on the risk and severity of injuries sustained by a child pedestrian, particularly if the child's head makes contact with the rigid windshield (103). Vehicle designers are now examining ways to reduce the severity of pedestrian injuries. In particular, bumpers are being redesigned so as to prevent a pedestrian's head making contact with the front window, by allowing the impact to be absorbed by a softer bonnet (104). The adaptations of vehicle design that have successfully reduced the incidence and severity of injuries in collisions between adult pedestrians and vehicles are now being modified to benefit children.

“Back-over” injuries – usually in a driveway or parking lot – result when a car is reversed over a small child. Children aged between 1 and 3 years are at particular risk because of their small size and their inability to alert the driver. Unfortunately, with the increased demand for sports utility vehicles, such injuries are becoming more common (105, 106). Many vehicles are now being fitted with reverse backup sensors that could help reduce the incidence of such injuries (107).

As regards bicycle-related factors, about three quarters of the crashes in the Netherlands involving passengers – often children – carried on bicycles are associated with feet being trapped in the wheel spokes, and 60% of bicycles have no protective features to prevent this from occurring (108). Ergonomic changes in the design of bicycles can thus lead to an improvement in bicycle safety (108, 109).

Environmental factors

It is normal for children to carry out activities in the road environment – such as cycling, walking, running, playing and other common group activities. It is also important for their healthy development that children, from an early age, undertake such activities. For this reason, it is important

for the road environment to be safe so that these activities can be undertaken without the child's safety being put at risk.

Motorization and urbanization are proceeding rapidly in much of the world today. Increased and more rapid mobility tend to be the goals, while safe mobility – and particularly the safety of children – are rarely taken into account. A number of specific environmental factors increase the risk for children using the road system. These factors include the following:

- sites with a volume of traffic exceeding 15 000 motor vehicles per day;
- poor planning of land use and road networks, including:
 - long, straight through-roads that encourage high vehicle speeds, together with mixed land use made up of residential housing, schools and commercial outlets (110, 111);
 - a lack of playgrounds, resulting in children playing in the road;
 - a lack of facilities to separate road users – such as lanes for bicyclists and pavements for child pedestrians (112, 113);
 - the existence of street vendor businesses, in which children may work;
- a lack of safe, efficient public transportation systems;
- inappropriate speed, particularly in residential areas where children play or walk to and from school (97, 113–115);

Lack of prompt treatment

Good recovery from road traffic injuries depends upon the availability, accessibility and quality of trauma care services. Such services are either not available or else are limited in scope and capacity in many low-income and middle-income countries. The surveys conducted in Asia brought out the fact that numerous children are injured who do not receive medical care. In Beijing, this ratio of those receiving care to those injured was 1:254, while in Thailand it was 1:170 (15).

The most critical problems in relation to pre-hospital and emergency care in many low-income and middle-income countries are (116, 117):

- a lack of first-aid services and trained personnel;
- unsafe modes of transportation to reach emergency care;
- the long delay between the time of injury and reaching a hospital;
- inappropriate referral services;
- the absence of a triage system.

The availability of good rehabilitation services is also an important requirement for the proper recovery of children following a road traffic injury. Again, such services may be limited in many countries due to the lack of rehabilitation personnel, the necessary infrastructure and the availability of guidelines and protocols for rehabilitation.

Interventions

Much has been written over the past decade about how best to reduce the incidence of road traffic injuries. The *World report on road traffic injury prevention* describes proven interventions and makes six recommendations to prevent road traffic injuries at country level (1). Promoting the systems approach, the report's recommendations are equally applicable to the prevention of road traffic crashes involving children. There are a number of interventions, though, that focus specifically on children.

The systems approach is of particular value in child road safety since it moves away from the idea that children should adapt their behaviour to cope with traffic, in favour of an approach that recognizes that children's needs should be addressed in the design and management of the whole road system.

Success in improving safety for children is most likely to be achieved through a holistic approach combining measures to address the behaviour of all road users, to improve the road environment and to design vehicles that better protect both their occupants and those at risk outside the vehicle (27).

The following sections discuss interventions that target younger road users.

Engineering measures

Creating a safe environment for children requires that space for walking and cycling is given priority and not treated as an afterthought, after space for motorized traffic has been designed. The routes that children are likely to take to reach schools, playgrounds and shops, and how these routes can be integrated into a logical, coherent and safe network for walking and cycling, need to be considered (118). Greater attention should be given to how the built environment can safely cater for the healthy pursuits of walking and bicycle riding, while at the same time focusing on sustainable public transport systems.

Reducing speed

The policies of both Vision Zero in Sweden and sustainable safety in the Netherlands promote the design of roads and the setting of speed limits that are appropriate for the function of the road (119, 120). Survival rates for pedestrians and cyclists are much higher at collision speeds of below 30 km/h (1). This speed should be the norm in residential areas and around schools. Various measures to achieve appropriate speeds should be considered (26), including:

- traffic-calming measures that reduce the speed of traffic through infrastructural engineering measures, such as:
 - speed humps;
 - mini-roundabouts;
 - designated pedestrian crossings;
 - pedestrian islands;

- visual changes – such as treating the road surface, and improving the road lighting;
- the redistribution of traffic – by blocking roads, and creating one-way streets near schools.

Where a higher speed limit is allowed there should be provision to keep pedestrians and cyclists separate from traffic by using single-lane roundabouts, footways, pedestrian signal phasing and pedestrian refuge islands, and to improve safety with better street lighting (121).

Managing speed is problematic in many low-income and middle-income countries, where the effectiveness of many infrastructural measures proposed for high-income countries has yet to be tested (122, 123). Some speed reduction measures have indeed been shown to be affordable and sustainable in urban areas, such as successful introduction of speed humps in Ghana (124). The problem is how to protect vulnerable road users, particularly children, on rural roads, many of which lack essential infrastructural requirements.

Safe play areas

Children need access to safe spaces for play and physical exercise. If such spaces are not available, children will be tempted to play on the streets. Play spaces should be secure and well maintained, with features that children find interesting. Designing safe play areas should be incorporated into urban planning and the development of school facilities and residential complexes. In the Dominican Republic, UNICEF is working with local government authorities to develop safe play areas, under the “Child Friendly Cities” programme. Working in consultation with children and adolescents, a team of architects have planned parks where children can play safely (125).

Safe routes to school

Much effort has been spent on designing ways of getting to school, particularly for children of primary-school age. The measures include the provision of buses to transport children to school and encouraging children to walk to school, using the concept of “walking buses”. In the latter, adult volunteers accompany groups of children, who walk along safe routes wearing conspicuous, possibly fluorescent, vests. Walking buses teach children how to walk safely, as well as teaching the health benefits of walking. They also reduce traffic congestion and pollution, particularly near schools (126). Although this measure has been implemented in a number of developed and developing countries, with clear health and social benefits (127), its effectiveness in reducing the incidence of child traffic injuries has yet to be calculated.

Some schools in high-income countries have engaged a “school travel coordinator”, who advises teachers and parents on the safest routes to school. However,

a randomized control trial conducted in the United Kingdom failed to show that the preparation of school travel plans had an effect on how children travelled to school (128).

Many countries have introduced school safety zones, that include car-free areas, speed reduction measures and adult supervision to cross the road safely. In Thailand, for example, the areas around schools have been comprehensively improved and educational programmes introduced on safe routes to school. In Bangalore, India, the focus has been on better public transport, making vehicles park or stop at a given distance from the school, dedicated school buses and pedestrian crossings near selected schools, sometimes overseen by traffic wardens (129).

Separation of two-wheelers

Child cyclists need to be separated physically, by barriers or kerbs, or else by the demarcation of white lines, from other road users (130). In Denmark and the Netherlands, where there are large numbers of cyclists, bicycles are a feasible means of child transport if safety concerns are properly addressed. A meta-analysis of the effects of cycle lanes found an estimated 4% reduction in the incidence of injuries (122).

Exclusive motorcycle lanes, separated from the main carriageway by a raised central reservation, have been shown to reduce the likelihood of crashes. In Malaysia, where there are large numbers of young motorcyclists, reductions in crash rates of 27% have been recorded since motorcycles were separated from the rest of the traffic (131).

Vehicle design

Vehicle design and standards contribute to the safety of children both inside and outside the vehicle. Primary safety measures for vehicles – to prevent a crash – such as braking and lighting systems, improve road safety in general but are not specifically designed for children. Some secondary safety measures, though, are child-specific. They may be either active or passive.

- Modern vehicles are designed with energy-absorbing *crumple zones* and *side impact bars* to limit the extent to which the vehicle will intrude into the passenger compartment in the event of a collision, thus reducing potential injuries to children (1).
- *Redesigning car fronts* has the potential to reduce injuries to pedestrians, and to children in particular, as they are vulnerable to head injuries on impact (1). The New Car Assessment Programmes in Europe, the United States and Australia include ratings for pedestrian protection, but most vehicles still obtain low scores. A new European Directive will, by 2010, require new car models to pass a crash test incorporating protection requirements for pedestrians.

- Motor manufacturers should help protect children in vehicles by providing suitable facilities to fit *child restraints*. Vehicles with these improved designs will result in children being less likely to strike the car's interior in case of an impact (132).
- Children are at risk when vehicles are reversing. The development of *better visibility aids*, such as cameras, and use of *audible alarms* and *reversing lights* can all help prevent injuries caused in this way (107).
- *Alcohol interlock systems* are beginning to be used in some countries. They require a driver to blow into a device before starting the car. The ignition will not function if alcohol is present. Such devices have led to reductions of between 40% and 95% in the rate of repeat offending under drink-driving laws (1). The devices are therefore valuable for adolescents who drink and drive.

Safety equipment

Child restraint systems

Appropriate child restraint systems are designed to take account of the child's developmental stage. Like seat-belts, they work to secure the child to the vehicle in a way that, in the event of a crash, distributes forces over a broad body area, thus reducing the chance of a severe injury occurring. Three types of restraint systems for child passengers are used:

- rear-facing restraints for infants;
- forward-facing child restraints;
- booster cushions or booster seats, for older children.

These systems take into account a child's physical dimensions and proportions.

Child restraint systems are very effective at preventing fatalities, and are the most important "in-vehicle" safety measure for children. In the event of a crash, if restraint systems are properly installed and used, they can:

- reduce deaths among infants by around 70% (133);
- reduce deaths among small children, aged 1–4 years, by 54% (133);
- reduce the chances of sustaining clinically significant injuries by 59% among children aged 4–7 years who are strapped in booster seats, as compared to the rate of injuries sustained using ordinary vehicle seat-belts (134).

Despite the overwhelming evidence of their effectiveness, though, many children are not restrained in age-appropriate child or booster seats.

In many high-income countries the use of child restraints is common, with usage rates as high as 90%. Elsewhere, though, child restraints are still rarely used. Choosing and installing the appropriate child restraint system is important. Even in countries where the use of child restraints is common – such as in Sweden, the

United Kingdom and the United States – restraints are frequently used inappropriately. A child may, for instance, be restrained in a device that is wrong for its age or weight, or the straps or harnesses may be inadequately secured or may be left entirely undone. In all these situations, the child is placed at increased risk of both fatal and non-fatal injuries (133, 134).

In many places, the use of child restraints may be limited by access or cost, or else may not be practical because of the many children in the family. In addition, parents need to be aware of what type of seat to choose, where to place it and how to install it. Research in Greece found that 88.4% of parents placed their children unrestrained on the back seat, while 76.1% of those who used a restraint did not do so consistently (135).

A number of measures have been shown to increase the use of child restraints.

- Mandatory laws on child restraint use and their enforcement can lead to reductions in the rate of severe or fatal crash injuries.
- Public awareness can be raised through publicity campaigns emphasizing the need for appropriate restraints for children of different ages (136). Such campaigns are most effective when backed up by enforcement.
- Appropriate restraints can be subsidized or distributed free to families. Loan schemes have been used in some countries, thus increasing both the accessibility and affordability of appropriate restraint systems (137, 138).

A rear-facing child safety seat should never be placed in front of an airbag (139). Recent research suggests that children whose restraints are placed in the centre rear seating position incur less injuries than those placed on the outer seats, though this contradicts earlier studies that found that the centre seat was a less safe position (140, 141). Although children are best protected when secured in age-appropriate child restraints, where such restraints are not available it is still better to use an adult seat-belt on the child than to leave the child wholly unrestrained on the back seat (142, 143).

Seat-belts

For children over the age of 10 years, or above 150 cm in height, normal seat-belts should be used. Like child restraints, they serve to keep the child away from the vehicle structure in the event of a crash, prevent ejection from the vehicle, and distribute the forces of the crash over the strongest parts of the body.

Wearing a seat-belt reduces the risk of being ejected from a vehicle and suffering serious or fatal injury by between 40% and 65% (144). However, rates of seat-belt use vary widely between countries, in large part as a result of the differing enforcement of seat-belt laws (1). In general, though, seat-belt use among adolescent passengers and

drivers is noticeably less than among older occupants (29).

As with child restraints, seat-belt use can be improved through:

- introducing and enforcing a law mandating seat-belt use;
- requiring all vehicles to be fitted with appropriate seat-belts;
- conducting public awareness campaigns on seat-belts, targeted at young people.

Such measures can increase awareness about the benefits of wearing seat-belts and help make seat-belt use a social norm among young people.

Bicycle helmets

A child's brain is particularly vulnerable to injury. Approximately two thirds of hospital admissions among cyclists are for head injuries, and three quarters of deaths among injured cyclists are from head injuries (64).

Helmets for cyclists afford protection from head injury in both traffic crashes and falls. The strongest evidence for the effectiveness of helmets comes from case-control studies. A systematic review of five such studies found that helmets reduced the risk of head and severe brain injury by between 63% and 88%, among cyclists of all ages (64). The use of cycle helmets is particularly important for older children because of their increased exposure to traffic. Helmets should be designed to match the age of the child, and when purchasing helmets parents should ensure that they are the appropriate size and fit the child's head.

A number of measures have been shown to increase the use of cycle helmets among children, including:

- laws on bicycle helmet use and their enforcement;
- the promotion of bicycle helmets among children;
- public awareness campaigns.

Although the question of bicycle helmet use as it relates to adult use has been controversial (26), promoting helmet use among children, whose basic motor skills are still developing, is more generally accepted. In the Netherlands, for instance, the road environment has been modified to make it very safe for cycling. Although there is no law on bicycle helmet use, Dutch crash data show that children in the 4–8-year age group are particularly likely to be involved in bicycle crashes and suffer head injuries, and thus helmet use among children is strongly promoted (145). While some countries, such as Australia and the United States, have introduced and enforce mandatory bicycle helmet laws for all cyclists, others have laws stipulating an age below which children must wear helmets (27). Data from before and after such laws were passed show an increase in helmet use – suggesting that reductions in head injury rates can be achieved through this strategy (27).

Motorcycle helmets

In most high-income countries young children are rarely seen on the backs of motorcycles. However, in many places, especially in parts of South-East Asia, children are routinely transported as passengers on motorized two-wheelers. It is therefore important to protect these children by ensuring that they wear appropriate helmets (Box 2.3).

Helmets, as already stated, reduce the risk of serious head and brain injuries by lessening the impact of a force to the head. Wearing a helmet is the single most effective way of preventing head injuries and fatalities resulting from motorcycle crashes (26).

Wearing a helmet on a motorcycle (70):

- decreases the risk and severity of injuries by about 72%;
- decreases the likelihood of death by up to 39%, with the probability depending on the speed of the motorcycle involved;
- decreases the health-care costs associated with crashes.

A number of factors work against the wearing of helmets among child motorcycle passengers, including the following.

- Passengers on motorcycles may be exempt from mandatory helmet wearing laws or exempt from fines.
- Standard child helmets may not be available.

- The cost of purchasing child helmets may be prohibitive. Studies have shown that in some low-income countries, to afford a motorcycle helmet, factory workers have to work 11 times longer than their counterparts in high-income countries (146).
- Risk-taking behaviours among adolescent motorcycle riders may result in their not wearing helmets. In a study in Brazil, those under 18 years were significantly less likely than older people to wear a helmet, particularly if they had been consuming alcohol (147).

Conspicuity

Conspicuity is the ability of a road user to be seen by other road users. Vulnerable road users are at increased risk for road traffic injuries if they are not seen in time for the other road users to take evasive action and avoid a collision. Children, whose small stature means that they are less likely to be seen by motorists, are at even greater risk of not being seen.

Improving the visibility of non-motorized road users is one way to reduce the risk of a road traffic crash, as it gives drivers more time to notice and avoid a collision. Interventions to increase conspicuity include the following.

- Retro-reflective clothing or strips on backpacks can increase the visibility of both pedestrians and

BOX 2.3

Getting helmets on children's heads: the experience of Viet Nam

Since 1999, the Asia Injury Prevention Foundation in Hanoi has worked hard to get more people on motorcycles in Viet Nam to wear helmets and by doing so cut the rate of road traffic injuries among children. It has staged public awareness campaigns, lobbied the government, helped develop helmet standards for both adults and children, distributed child helmets along with information on their use, and pushed to increase the production of helmets.

At the end of 2007, the Vietnamese government passed a law making helmet wearing compulsory for drivers and passengers on motorcycles. Following its introduction, rates of helmet use soared to over 90%. At the same time, hospitals began reporting reductions in the number of deaths and brain injuries resulting from motorcycle crashes.

Soon, however, certain problems arose. It was pointed out that although helmets for children under 14 years were required by the new law, there was no provision to fine motorcycle drivers carrying children who were not wearing helmets. Furthermore, some doctors publicly questioned whether helmets might have an adverse effect on the development of a child's skull, suggesting that the weight of a helmet could lead to serious neck injuries among children involved in collisions. As a result, parents were less enthusiastic about putting helmets on their children's heads.

While the proportion of adult motorcyclists using helmets remained at over 90%, helmet use among children under the age of 7 years fell to between 10% and 25% in the large cities. Most parents quoted the risk of serious neck injury when asked why they avoided helmets for their children.

An effort is currently being made to tackle this problem, with measures including:

- public education on the facts regarding children and helmet use, including publishing in newspapers assurances signed by international experts;
- collaboration with the government to remove the loophole in the law, whereby drivers were not penalized if their child passengers were without a helmet;
- further research on standards for child helmets.



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cyclists. Although this intervention aids visibility, its actual effectiveness in reducing injuries still needs to be evaluated (148). Some programmes using this technique, though, are beginning to show promise (149–151).

- Daytime running lights for motorcyclists have been shown to be effective in reducing fatalities in countries, including Malaysia and Singapore, that have large numbers of motorcycles (152, 153).
- The colour of the helmet seems to have an effect on the conspicuity of motorcyclists. A case-control study in New Zealand found that retro-reflective or fluorescent clothing, white helmets and daytime running lights were all effective in reducing crashes (154).

Legislation and standards

Setting and rigorously enforcing road safety regulations may prevent up to half of all deaths and serious injuries (155). As with all other road safety interventions, most laws which are designed to prevent crash injuries in the general population will also help reduce the incidence of child road traffic injuries. Some laws, though, are specific to children and young people.

Motor vehicle licensing

In most countries the minimum age for obtaining a licence allowing unaccompanied driving is 18 years, though in some places the minimum age is as low as 16 years (1). Driver licensing systems exist to regulate the entry of new drivers and to control the conditions under which they learn to drive. These systems involve both a test on theory and a practical driving test, usually conducted in normal traffic during the day. The driving test is intended to ensure that new drivers fulfil certain minimum performance standards and to identify drivers who are unfit to drive (122).

Novice drivers are over-represented in crash statistics. As a result, many countries have introduced graduated driver licensing systems that place restrictions on new drivers, typically for the first two years of their driving (see Box 2.4). As well as restricting young drivers, the graduated driver licensing system serves to increase the amount of accompanied driving time an adolescent has – something that has been shown to produce positive results in preventing crashes (53).

Motorized two-wheeler licensing

In many countries children over 14 years of age are allowed to drive light mopeds with a maximum speed of 25 km/h, while more powerful mopeds, with a maximum speed of 45 km/h, and motorcycles are only permitted at 16 years. Raising the age limit for all powered two-wheelers from 16 to 18 years has been found to be effective in reducing the number of road traffic casualties (156, 157).

Drink-driving laws

Various methods have been adopted to restrict drinking and driving among younger drivers, including the following.

- *Setting lower blood alcohol concentration limits* for younger drivers. The risk of a crash for inexperienced young adult drivers starts to rise at significantly lower blood alcohol concentration levels than is the case for older drivers. For this reason, many countries have set a lower blood alcohol concentration limit – usually between zero and 0.02 g/dl – for drivers under the age of 21 years. These lower limits may cut the incidence of crashes among young or novice drivers by between 4% and 24% (158).
- *Enforcing blood alcohol limits.* Consistent enforcement of blood alcohol concentration limits is essential for the law to be effective. There are two basic ways in which this can be done.
 - Sobriety checks, or selective breath-testing. In these checks, drivers are stopped at checkpoints or roadblocks and only those suspected of being over the alcohol limit are tested. This approach has been shown to be effective in cutting the number of alcohol-related crashes by about 20% (159).
 - Random breath-testing. This involves stopping drivers at random and breath-testing them. Australia, New Zealand and some European countries use this strategy with excellent results (160). An Australian study has found random breath-testing to be twice as effective as conducting sobriety checks at selective checkpoints (161).
- *Raising the legal drinking age.* Minimum drinking-age laws specify an age below which the purchase or public consumption of alcoholic beverages is illegal. The laws may also include penalties for the possession or consumption of alcohol by those under that age. Evidence from the United States, where over the last few years every state has raised the legal drinking age to 21 years, suggests that laws on the minimum legal drinking age have reduced drinking, driving after drinking, and alcohol-related crashes and injuries among young people (158, 162). However, in many places, the enforcement of the law is very lax.

Child restraints

Mandatory child restraint laws and their enforcement lead to an increase in the use of child restraints, and some studies show a corresponding reduction in traffic-related deaths and injuries among children. In some countries a penalty-point system is used to encourage people to comply with the legislation. In Latvia, the law on the use of child seats was revised in 2006 so that the penalty points could be incurred for failing to use a restraint.

The effectiveness of such laws, though, will depend on how correctly child restraints are used. A study in Japan

BOX 2.4

Graduated driver licensing programmes

Beginner drivers of all ages lack skills in driving and in recognizing possible dangers, and are therefore at increased risk of a crash. In the case of newly-licensed adolescent drivers, their immaturity combined with limited driving experience can result in a disproportionately higher rate of crashes. Graduated licensing systems are schemes that allow for a controlled and supervised phasing-in of full driving licences for young novice drivers. The schemes protect beginners while they are learning, allowing them to obtain experience on the road under conditions of low risk. Graduated driver licensing is widely used in many high-income countries. Although the schemes vary between countries, most of them consist of a three-stage model.

- Stage 1: an extended period as a learner driver. The purpose of this stage is to increase the amount of supervised driving experience before receiving a full licence.
- Stage 2: a provisional or intermediate licence. Such a licence will contain temporary provisions, such as restrictions on unsupervised driving, late-night driving and driving with young passengers.
- Stage 3: a full licence.

In many countries, progressing from one stage to another requires a certain number of supervised driving hours. There may also be stipulations that a proportion of these hours should be conducted at night-time.

The areas that graduated driver licensing schemes typically address include the following.

- *Alcohol restrictions.* Permitted blood alcohol concentrations limits range from zero in some countries to levels somewhat below the levels for experienced drivers – for instance, 0.02 g/dl, against 0.05 g/dl for drivers with full licences.
- *Passenger restrictions.* In the first phase, most graduated driver licensing systems do not allow passengers in the same vehicle. In the second stage, passengers are usually allowed, but only if a parent or supervisor is present during the first three months, after which only immediate family are permitted as passengers.
- *Seat-belt use.* Almost all graduated driver licensing systems require that drivers and other occupants wear seat-belts.
- *Speed.* In some countries, drivers at the learning stage are prohibited from driving on any highway with a speed limit of over 80 km/h.
- *Restrictions on driving at night.* Drivers in the first stage are prohibited in some places from driving between midnight and 05:00.
- *Mobile phone use.* A number of countries have recently introduced restrictions on mobile phone use, even with hands-free devices.

Evaluations of graduated driver licensing systems have reported significant reductions in crashes and fatalities. Estimates of their effectiveness have ranged from 4% to 60%, reflecting differences in the systems, in the drivers' ages and in the methodologies used in the evaluations (163, 164). Recent data from the United States have shown a 23% reduction over a decade in crashes among 16-year-olds, with greater reductions for night-time driving and driving with occupants. The single most effective provision within graduated driver licensing schemes appears to be the extension of Stage 1, the learner period, which delays unsupervised driving (165).



tried to assess the impact on child injuries of laws mandating the use of child restraints. Despite overall increases in the use of child restraints, overall rates of fatalities and serious injuries among children aged 1–5 years did not change after the law was introduced, possibly because the restraints were not being used properly (166).

Helmets

Legislation and the enforcement of mandatory helmet use for moped and motorcycle users is an effective intervention measure, particularly where accompanied by public awareness campaigns. In countries where these laws are enforced, helmet-wearing rates have been found to increase to 90% or higher. In places where existing laws have been repealed, wearing rates have fallen back to generally under 60% (26). Standards for helmets should also be enforced, including provisions for helmets for children. Some countries, such as Malaysia, have already

extended their standards to include helmets designed specially for children (26, 152).

Developing education and skills

Education can improve skills, behaviour and attitudes. A systematic review of safety education for pedestrians found an improvement in behaviours and attitudes that predispose people to risk-taking, but none of the studies reviewed actually recorded a reduction in injuries (167). Follow-up longitudinal studies would be needed among those children whose attitudes were changed by educational approaches to see if their risk of injury was diminished (168), though such a study would be long and expensive.

Traditionally, road safety education has been conducted in the classroom and has often involved an approach based on teaching children the rules of the road. What has usually been absent in educational programmes is the

application of modern ideas on educational and behaviour change. Social scientists working in injury prevention have in recent times taken an increasingly ecological approach, one that involves the interaction between the fields of child development, educational theory and behavioural theory (169).

Younger children

Current research on road safety education suggests that an approach that stresses behaviour, focusing on the development of practical skills, is more likely to be effective for younger children. Children learn best through methods that develop problem-solving and decision-making skills. Young children also learn by example.

In any case, education is an important ingredient of any comprehensive effort to prevent injury. Some examples of effective educational approaches include the following.

- *Roadside skills development* for 6–8-year-olds. Such programmes include the Kerbcraft pilot programme in the United Kingdom that teaches a number of basic skills, such as finding a safe place to cross, crossing safely near parked vehicles, and crossing safely at junctions (170).
- *Simulated environments* that teach pedestrian and cycle skills in a safe setting off the road. Examples include the “Safety City” programmes in New York City and Puerto Rico, and traffic gardens in the Netherlands. Such programmes need to be used as part of a progressive programme, as they cannot address real interactions with traffic.
- *Basic cycle skills* can be taught both on and off the road. The Oregon bicycle education curriculum has ten modules, half of them conducted on the road. While skills are developed, evidence as regards the extent of injury prevention is lacking (171).
- *Conspicuity* is covered in many pedestrian educational programmes. In Norway, children receive caps, vests or bags in bright colours with retro-reflective materials to make them more visible, especially on dark winter evenings. In South Africa, the Drive Alive Pedestrian Visibility Campaign that does public education work has campaigned for laws to make it compulsory for all school uniforms to contain retro-reflective material, so as to increase the visibility of child pedestrians (149).

Adolescents

By the time children reach adolescence they should have mastered the skills needed to act safely as pedestrians and cyclists, though some choose to engage in risk-taking behaviour. This is a difficult age group to reach through educational approaches and some methods may even be counterproductive. Greater involvement of adolescents in designing programme may be helpful (172), as may the use of television programmes, such as “Soul City”

(173, 174), theatrical presentations, games and peer education.

Young drivers

The controversy over the effectiveness of school-based driver education has a long history (139). Both the randomized controlled trials conducted in 1999 (175) and those done by the Cochrane Injuries Group in 2001 (176) found that driver education did not reduce the number of traffic crashes or violations among students. On the contrary, driver education programmes can lead to earlier driving by novices, resulting in more crashes (139) offsetting any benefits from driver education programmes. A more recent randomized trial of the effectiveness of post-licence driver education in preventing road traffic crashes has also found no evidence of effectiveness (177).

Emergency and trauma care

Most initiatives for cutting the incidence of road traffic injuries focus on preventing crashes and on restricting the extent of their consequences. Much, though, can be done to reduce the number of deaths and injuries from road traffic crashes by strengthening the emergency medical services – including pre-hospital care, hospital care and rehabilitation.

Pre-hospital care

At the scene of the crash, prompt, efficient and effective pre-hospital care can save many lives. In places where formal emergency medical services exist, usually with ambulances, they are most effective if their equipment, training, infrastructure and operations are standardized. These emergency vehicles need to be equipped with supplies and medical devices for children as well as for adults – such as airway tubes, cervical collars and blood pressure cuffs. Staff need to be trained on how to evaluate and manage injured children, and to recognize that what is normal in an adult may not necessarily be normal in a child. Where no pre-hospital trauma care system exists, the first and fundamental tier of the system should be established by teaching interested volunteers the basic techniques of first aid (178). In many countries, organizations such as the International Federation of Red Cross and Red Crescent Societies, and the St John’s Ambulance teach young people how to recognize an emergency, call for help and provide basic first aid until formally-trained health-care personnel arrive.

Setting up a new emergency medical service may be a valuable step, especially along busy roads with high crash rates. These services, though, can be costly. In all cases, and especially where there are no formal emergency medical services, pre-hospital care can be improved by building upon existing – even if informal – systems of pre-hospital care and transport (178).

Trauma care

Entry into the hospital is the second stage at which the life of an injured child can be saved (179). Improving the organization of trauma care services is an affordable and sustainable way of raising the quality and outcome of care. This involves improving the human resources that are required to provide care – including skills, training and staffing – and the physical resources, including equipment and supplies. The essential elements of trauma care need not be expensive, though the cost of care is often a barrier to access, especially where user fees are required in advance of services in emergency situations.

Rehabilitation

Many injured survivors of traffic crashes lead lives of disability. Much of this disability, particularly among young people, could be avoided with improved rehabilitation services. This includes improved services in health-care facilities and improved access to community-based rehabilitation. Such rehabilitation services need to be strengthened everywhere, so as to reduce the prevalence of disability after injury and to help those with persistent disabilities to lead full and meaningful lives.

Potentially harmful interventions

Airbags deployed in the event of a sudden deceleration are designed to supplement, and not to replace, the protection provided by a seat-belt. Although they have proven benefits for adults, airbags pose serious risks for children. Available data indicate that, on average, children under the age of 13 years are more likely to be harmed by an airbag than to be helped by it. Children should not sit in the front passenger seat of cars with airbags unless there is absolutely no alternative or unless the airbag has been deactivated (180). In most high-income countries, parents are warned about the danger of airbags to children and advised on the correct seating positions to be used in vehicles where airbags have been fitted. A rear-facing child safety seat should *never* be placed in front of an airbag (139). Current research is focusing on new technological solutions that will detect the presence of a child and adjust the deployment of the airbag or deactivate it. Newer airbag designs have cut the number of injuries to children, without wholly eliminating such injuries, but have provided no additional benefit to adults (181).

Evaluating interventions

There is no single blueprint for road safety. Many of the interventions discussed in this chapter have been evaluated only in high-income countries. It is quite possible that they will also work in low-income or middle-income countries, but their feasibility, acceptability and effectiveness in these countries have yet to be tested. While some countries have begun to implement and evaluate road safety interventions in general, few countries have evaluated child-specific road

safety interventions and fewer still have looked at their cost-effectiveness. More evaluation studies are needed, so as to obtain compelling evidence that will persuade policy-makers to prioritize road traffic injury prevention, particularly as it affects children.

Conclusions and recommendations

Around 10 million children annually are estimated to be injured or disabled as a result of road traffic injuries. Road traffic injuries are the leading cause of death in children aged 10–19 years, and are also the leading cause of disability among children generally. Over the next 15 years, significant increases in road traffic casualties are predicted, particularly in low-income and middle-income countries. In India and China in particular, in that period, the annual incidence of road traffic fatalities is expected to at least double.

The road environment is constructed in most cases without consideration for children. Children on the road are therefore at greater risk than they need have been. Rises in motorization and urbanization are both fuelling road traffic tolls in many countries.

A child is more susceptible to road traffic injuries because of a smaller height and other less developed physical characteristics, including sensory facilities. Young children may unknowingly take risks on the road because they lack appropriate skills to act safely. Older children and adolescents may actively indulge in risk-taking behaviours, that are exacerbated by peer pressure. Children from poorer backgrounds are generally at greater risk of road traffic injury.

Recommendations

Traditionally, road safety measures for children have focused largely on road safety education – with the assumption that children must be taught how to adapt their behaviour to the demands of a motorized society. However, when used in isolation, without considering the safety of vehicles and road environments, educational measures do not deliver tangible and sustained reductions in deaths and serious injuries.

The systems approach has proved valuable in delivering greater road safety for children. It moves away from the idea that children should adapt their behaviour to cope with traffic, in favour of an approach in which children's needs are addressed in the design and management of the whole road system.

Large gains can be made in terms of injuries avoided and lives saved if proven and effective strategies – increasingly used in high-income countries – are adapted to the context of low-income and middle-income countries where children are at considerably higher risk (see Table 2.3). In line with the systems approach, the following actions are recommended to reduce the toll of child road traffic injury, death and disability.

TABLE 2.3

Key strategies to prevent road traffic injuries among children

Strategy	Effective	Promising	Insufficient evidence	Ineffective	Harmful
Introducing (and enforcing) minimum drinking-age laws					
Setting (and enforcing) lower blood alcohol concentration limits for novice drivers and zero tolerance for offenders					
Utilizing appropriate child restraints and seat-belts					
Wearing motorcycle and bicycle helmets					
Forcing a reduction of speed around schools, residential areas, play areas					
Separating different types of road user					
Introducing (and enforcing) daytime running lights for motorcycles					
Introducing graduated driver licensing systems					
Implementing designated driver programmes					
Increasing the visibility of pedestrians					
Introducing instruction in schools on the dangers of drink-driving					
Conducting school-based driver education					
Putting babies or children on a seat with an air bag					
Licensing novice teenage drivers					

Source: references 7 and 139.

- *Reducing speed.* Survival rates for pedestrians and cyclists are much higher at collision speeds of below 30 km/h. This speed should be the norm in residential areas, around schools and other play areas.
- *Separation of two-wheelers.* Child cyclists should be separated physically from other road users – for instance, by using dedicated cycle lanes. Exclusive motorcycle lanes, separated from the main stream of road traffic by a raised central reservation, have been shown to reduce motorcycle casualties and should be considered.
- *Vehicle modifications.* Several modifications are already being introduced in many high-income countries. This process needs to be accelerated in high-income countries, and considered, where resources allow, in middle-income and low-income countries.
- *Child restraint systems* should always be used in cars. These include: rear-facing restraints for infants; forward-facing child restraints; and booster cushions or booster seats, for older children.
- *Seat-belts.* For children over the age of 10 years, or above 150 cm in height, normal seat-belts should be used.
- *Bicycle helmets.* Appropriate helmets always should always be worn by children cycling on the roads as their heads are even more susceptible to injury than adults.
- *Motorcycle helmets.* Wearing a helmet is the single most effective way of preventing head injuries and fatalities resulting from motorcycle crashes. All drivers and passengers on motorcycles, irrespective of their ages, should wear approved helmets, appropriate for their head size and in a conspicuous colour.
- *Drink-driving laws.* Strict laws on drink-driving should be introduced and enforced. Methods include:
 - setting lower blood alcohol concentration limits for young drivers;
 - undertaking sobriety checks, or selective breath-testing;
 - undertaking random breath-testing;
 - raising the legal drinking age.
- *Daytime running lights* for motorcyclists have been shown to be effective in reducing fatalities in several countries, and should be considered as a preventive measure.
- *Novice drivers.* Countries should consider introducing graduated driver licensing systems that place restrictions on new drivers, for the initial period (possibly two years) of their driving.
- *Teaching knowledge and skills.* For younger children in particular, education is an important ingredient of any comprehensive effort to prevent injury. Measures include:
 - roadside skills development for 6–8-year-olds;

- simulated environments that teach pedestrian and cycle skills in a safe setting off the road;
- basic cycle skills, taught both on and off the road.

In addition to the various primary prevention measures recommended above, emergency medical care – both pre-hospital and hospital care – as well as rehabilitation services should be improved and equipped with the child in mind. Furthermore, emergency health-care staff should be trained on how to evaluate and manage injured children.

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