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ABSTRACT

Globally, injury and death due to road traffic crashes constitute a leading threat to public health. In Africa, the road traffic death rate for children is reported at 19.9 per 100 000 population, which is twice the world rate. Low- to middle-income settings indicate that pedestrians suffer the greatest proportion of road-traffic injuries and fatalities, in relation to passenger and driver injury deaths. In South Africa, pedestrian injuries are the leading cause of injury death amongst children younger than 15 years. Despite national recognition of the child pedestrian injury and death burden, there appears to have been an inadequate preventative response by existing networks, programmes and projects. This Chapter reviews proven and promising child-pedestrian injury prevention programmes and interventions. An in-depth search across all electronic databases for descriptive and evaluative documentation on local interventions was conducted.

The selection of reports was guided by the study aims and parameters using a coding system that identified the article in terms of their relevance to the research question and contribution towards the field of child pedestrian safety. Articles were organised and coded according to intervention type and core intervention dimensions. The Chapter reports on interventions that demonstrated a reduction in child pedestrian death, injury, injury risk, and/or improved pedestrian road safety behaviour. Programmes combining educational, engineering and/or enforcement strategies reported greater success at promoting pedestrian safety. Effective interventions usually involve a fusion of educational programmes, enforcement, environmental and engineering interventions, combining a variety of passive and active interventions to bring about a comprehensive appeal for individuals to learn in an interactive way within their environments.

Keywords: child pedestrian safety, education, enforcement, engineering, environmental design

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INTRODUCTION

This Chapter provides an overview of the epidemiology and prevention research into childhood pedestrian injury. It highlights proven and promising child pedestrian safety intervention research, on a national and international level, with the intention of informing readers about opportunities for preventative responses suitable for implementation in South Africa. The Chapter describes:

- a. The extent and epidemiology of child pedestrian injury in South Africa.
- b. Selected risk factors and contributors.
- c. The effectiveness of educational interventions as preventative responses.
- d. Enforcement measures.
- e. Environmental and engineering interventions.
- f. Multi-type interventions.
- g. Recommendations for the use of proven and promising interventions considered suitable for implementation in South Africa.

THE EXTENT AND EPIDEMIOLOGY OF CHILD PEDESTRIAN INJURY

The World Health Organization (WHO) Burden of Disease project indicated the highest road traffic death rates in the African and Eastern Mediterranean regions (McMahon, Gopalakrishna & Stevenson, 2008). The African region's road traffic death rate for children is nearly twice that of the world rate at 19.9 per 100 000 population (McMahon, Gopalakrishna & Stevenson, 2008). These fatality rates are likely to rise, considering the predicted overall increase in road traffic injuries in sub-Saharan Africa, by as much as 80% between 2000 and 2020 (Kopits & Cropper, 2003; Peden *et al.*, 2004). In these settings and in low- to middle-income countries in general, pedestrians are the most vulnerable of road users and suffer the

Terminology and definitions

Road traffic crash

A collision or incident that may potentially lead to an injury and involve at least one moving vehicle (McMahon, Gopalakrishna & Stevenson, 2008).

Road traffic injuries

Injuries that are fatal or non-fatal and incurred from a road traffic crash on a public or private road which the public has access to (Economic Commission for Europe, 2003; McMahon, Gopalakrishna & Stevenson, 2008). In Europe, road traffic fatalities are considered as a death occurring within 30 days of a road traffic crash (Economic Commission for Europe, 2003), while in South Africa the RTMC reports road traffic fatalities that occur within 6 days as a direct result of a traffic crash (RTMC, 2007).

largest proportion of traffic-related injuries and fatalities (Afukaar, Antwi & Ofosu-Amaah, 2003; Mabunda, Swart & Seedat, 2007; Matzopoulos, Norman & Bradshaw, 2004).

In South Africa, pedestrian fatalities comprise a significant share of the traffic injury burden in South Africa, with 36% of all road traffic deaths involving pedestrians (Road Traffic Management Corporation [RTMC], 2008). In 2008, 698 (13.2%) of the 5272 pedestrian deaths where age was known, involved children under the age of 15 years (RTMC, 2008). Male children are at greater risk (Hobday, 2008), with a fatality risk ratio of 1.4 to 1 (Hobday, 2008). Children between the ages of 5 and 9 years are at greatest risk from pedestrian death and injury, and comprise 49% of all child pedestrian fatalities (RTMC, 2008).

The occurrence of child pedestrian injuries is clustered around certain times of the day. The most common times for fatal injuries are weekday afternoons (Mabunda, Swart &

Seedat, 2007), indicating that such road crashes occurred in daylight (84%, n = 1015), but particularly at dawn and dusk, with most occurring during the week (Hobday, 2008). Since children, especially those aged between 5 and 9 years, have to get to and from school, they may be exposed as “commuters,” particularly if they walk to school, but also as they walk to and from the buses and cars that take them to school.

A high number of incidents appear to have occurred in and around informal settlements (Peden, 1998), which typically have a high population density of children, high housing density, fewer designated play areas, and higher than average household crowding (Montgomery, 2009; National Safe Kids Campaign [NSKC], 2004). Children in these settings are heavily dependent on walking as their primary means of transportation (Behrens, 2003). Children living in poor socio-economic conditions have been reported to cross the streets 50% more than those from non-disadvantaged ones, and are consequently more vulnerable to pedestrian injury and/or death (Macpherson, Roberts & Pless, 1998; Tester, Rutherford, Wald & Rutherford, 2004).

Rapid urbanisation has contributed to these high population densities and the inadequate separation of people and vehicles (Sukhai, Noah & Prinsloo, 2004). The development of informal settlements, particularly those located alongside highways and main arterial roads create a challenge where children and adolescents are forced to cross busy roadways to and from school. Pedestrian fatalities are also a problem in rural areas, with these a leading cause of death among male and female children (Swart, Laher & Seedat, forthcoming). Risk characteristics associated with the primarily rural area of Mpumalanga include poorer road conditions and less availability of emergency services (Muellemam & Mueller, 1996; WylieMat & Kimball, 1997). Furthermore, response time may be longer due to

delays in summoning help and the greater distances that may have to be travelled in the event of a crash (Brodsky, 1993; Zwerling, 2005).

RISK FACTORS

Child pedestrian injuries result from a highly complex interaction of many possible factors, with risk factors related to the child, physical, as well as social environments (Agran, Winn, Anderson, Tran & Del Valle, 1996; NSKC, 2004). A number of these require particular consideration in the development of safety interventions or policy.

Child vulnerability

The extent of the child’s physical, cognitive and emotional attributes and abilities, as well as aspects of their temperament and personality, contributes to their vulnerability (McMahon, Gopalakrishna & Stevenson, 2008; WHO, 2005). The small physical stature of children limits their ability to see oncoming vehicles or to be seen by vehicle drivers. As children’s sensory facilities are also less developed, they have difficulty seeing cars in their peripheral vision as well as locating the direction of the sound of an oncoming vehicle (Schieber & Thompson, 1996). Furthermore, children are easily distracted and have difficulty in focusing their attention on features of the road environment (Dunbar, Hill & Lewis, 2001), which probably accounts for the common occurrence of child pedestrian “dart-out” collisions (Pitcairn & Edlemann, 2000).

Even when children detect road hazards, safely negotiating the road environment is a complex task that requires the accurate assessment of vehicle distance and speed, driver behaviour and whether there is adequate time to cross the street (Schieber & Thompson, 1996). Processing and integrating all these aspects of information within a short period of time is difficult for a child and impedes their ability to identify safe places to cross the road and to identify safe gaps in traffic (Tabibi & Pfeffer, 2003;

Whitebread & Neilson, 1998). Children's level of perceptual and cognitive abilities, and their limited experience, thus manifest in skills insufficient for the safe negotiation of often complex road situations (Dunbar, Hill & Lewis, 2001). The smaller physical size of children also adds significantly to the severity of pedestrian injuries; children suffer more severe and multiple injuries that result in greater fatalities due to the impact of the vehicle bumper or bonnet edge to the head or chest of the small child (Peden *et al.*, 2004).

Supervision, the home and neighbourhood setting

Child pedestrian injuries commonly occur on residential roads adjacent or close to the child's home or school, whether in urban or rural settings (Bass, Albertyn & Melis, 1995). Residential neighbourhoods are built to accommodate cars. The common straight and wide road, which is equipped with road parking spaces, contributes to drivers travelling at higher speeds than is necessary (Zegeer, McMahon & Burden, 1998). Children however often consider residential roads as part of their living space and this frequently places them at risk of being vulnerable road users as they are often exposed simply by walking through a parking lot to their parent's vehicle, by playing in driveways, or even by chasing a ball in the front yard (Bass, Albertyn & Melis, 1995; Brison, Wicklund & Mueller, 1988; Schieber & Vesega, 2002). In high-density areas which often lack safe pedestrian walking or crossing facilities, such behaviour is often normalised (Bishai, DeFrancesco, Mahoney, Guyer & Gielen, 2003; Seedat, MacKenzie & Mohan, 2006). European safety policy makers and authorities have recognised the influential role that residential roads may play as a place where social interaction takes place, and where pedestrians should be better accommodated and even enjoy precedence (Avery & Avery, 1982; Rivara & Barber, 1985; Ward, 1991).

Children are more vulnerable, especially at the start of schooling when they are both increasingly physically mobile, afforded greater independence, and required to move from one area to another to various preschools or schools. Sixty to 70% of child pedestrian (younger than 10 years) injuries are attributed to the unprotected or improper crossing of the street and intersections (Harborview Injury Prevention & Research Centre, 1997, cited in MacComas, MacKay & Pivik, 2002). In South Africa, a hospital-based study in Cape Town highlighted the occurrence of pedestrian injury at times when children play or run errands in residential areas, especially during late afternoons. It found, however, that 24.3% of the injured children were supervised by adults at the time of injury (Bass, Albertyn & Melis, 1995). The lack of, or improper adult supervision is consistent with studies which report a more limited acknowledgement by caregivers of children's vulnerability as road users (Michon, 1981; Rivara, Bergman & Drake, 1989). There may be a range of reasons for this; for example, caregiver expectations of children's independence and abilities, and preoccupations with other priorities related to day-to-day survival (Bass, Albertyn & Melis, 1995).

Parents, older siblings, family and teachers are thus considered important road safety facilitators, with the responsibility of teaching or guiding children about safe road usage (Lartey, Price, Telljohann, Drake & Yingling, 2007; Museru, Leshabari & Mbembati, 2002). The perceptions and attitudes that teachers, communities and significant others hold towards child pedestrian safety and the interventions surrounding it, therefore, holds important implications for the prevention of child pedestrian injury. Child pedestrian injury victims and their parents and/or guardians reported that they were unaware of safer ways of walking along the road because of perceptions of (i) the risk of road traffic injuries as low, (ii) traffic injury not being a major problem in their community, and (iii) collisions

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as inevitable, and thus unpreventable (Museru, Leshabari & Mbembati, 2002).

Vehicle drivers and their vehicles are also important contributing factors to pedestrian injury. Vehicle speed influences both the frequency and the severity of child pedestrian injuries. Faster moving vehicles require a longer braking distance and make it difficult for the driver to avoid impact with a child in the road. Furthermore, most pedestrians (80%) are killed at impact speeds of 50km/h and above, whereas most (90%) would survive if hit by a car travelling 30km/h (Peden *et al.*, 2004). In residential neighbourhoods, an average vehicle speed of 30 mph (48km/h), compared with 20 mph (32km/h) was associated with more than a seven times greater risk of children being hospitalised for pedestrian injuries (Jacobsen, Anderson, Winn, Moffat, Agron & Sarkar, 2000).

Vehicle design also has a significant effect on the severity and distribution of pedestrian injuries caused by vehicle impact (Simms & Wood, 2009). Sport utility vehicles, pick-up trucks and vans are more likely to cause severe injuries and death to children than are passenger cars (DiMaggio, Durkin & Richardson, 2006; Starnes & Longthorne, 2003). When struck by a higher elevated vehicle, smaller pedestrians are often thrown forward or knocked to the ground and run over instead of rolling up onto the vehicle's hood. The drivers of higher elevated vehicles with a larger frontal configuration also may be more likely to have their view of smaller child pedestrians obstructed (Starnes & Longthorne, 2003). Hence vehicle front end design, especially for Local Transport Vehicles (LTVs), should be considered in future motor vehicle safety standards.

Societal challenges

The unprecedented growth of motorisation and urbanisation has produced an environment which is reported as hostile to children in South Africa (Bass, Albertyn & Melis, 1995). Over five thousand

potentially high-risk road locations have been identified across rural and urban settings (Ribbens, 1998), with nearly 40% of pedestrian fatalities occurring on rural roads (Erasmus & Van Vuuren, 2004). A large proportion of the South African population either travel by foot or public transport, with 20% utilising private transport (Ribbens, 1998). South Africa thus has a low rate of vehicles per population (7.63 vehicles/1000 population), as compared with HICs, such as the USA (42.37/1000), UK (35.11/1000), France (34.73/1000), Netherlands (30.37/1000) and Australia (29.1/1000) (World Road Statistics, 1994, cited in Ribbens, 1997). Furthermore, the proportion of unroadworthy and unregistered vehicles is expected to increase on South Africa's roads (Peden *et al.*, 2004).

TRAFFIC INTERVENTIONS PROMOTING CHILD PEDESTRIAN SAFETY

There exists a broad range of traffic interventions that can potentially be used in different forms and contexts to improve the safety of pedestrians. The traffic interventions described in this Chapter are specific to the reduction of child injuries and related injury risks. Three main pedestrian intervention categories are reported on: pedestrian safety education, enforcement measures and engineering-type interventions (including both design and environmental safety solutions) (Stevenson & Sleet, 1997).

Education for child pedestrian safety

Road safety educational programmes that aim to reduce pedestrian injuries generally focus on equipping individuals with knowledge and skills to safely manage the traffic environment. Pedestrian-safety education can improve children's knowledge and observed road crossing behaviour, but the extent to which this reduces actual child pedestrian injury occurrence is unknown (Duperrex, Roberts & Bunn, 2002). Education can prepare children to become safe and independent road users (Quimby, 2001)

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by developing road safety knowledge and skills, and is regarded as an important component of a comprehensive strategy to prevent child pedestrian injuries (Duperrex, Roberts & Bunn, 2002; Wyke, Capleton, O'Connell, Duarte-Davidson & Health Protection Agency, 2007).

The school curricula in mainly the low- and middle-income countries either provide no or little road safety education (RSE) to their students. In South Africa, RSE, specifically targeting children is considered to be a neglected intervention (Lötter, 2004). Though efforts to improve the pedestrian road safety situation has been addressed by the South African Department of Transport (DoT) with the launch of the Arrive Alive Road Safety Campaign in 1997, this campaign seeks to promote road safety to the general population through the use of informative posters, road safety magazines, video clips on road safety and information on rules of the road and traffic signs (Arrive Alive, 2009a). Even though these educational programmes are reported to have reached 80% of television viewers and 90% of radio listeners, no independent impact studies were performed on this national road safety initiative. The scholar or school patrol programme, originally developed by the American Automobile Association (AAA) and subsequently implemented by the DoT was meant to have a similar outcome. Its aim is to instil the importance of road safety behaviour amongst learners, to regulate traffic, improve speed calming measures and to ensure the safe(r) crossing of roads (Arrive Alive, 2009b).

Child pedestrian safety educational programmes have been extensively implemented in high-income countries in a variety of settings, including the home, school and community. They have been targeted either directly at children or at children with parents and teachers and employ a range of methods, such as classroom instruction, the use of audiovisual materials, including board and computer games, and educational training and practice in real

and simulated traffic situations (see Schwebel & McClure, 2010). A number of key elements or good practices have been identified that contribute to the effectiveness of child road safety educational programmes (Desimini, Fox, Geise, Lee & Parker-Toulson, 2009). These include:

- The development of practical skills in either real or simulated traffic situations.
- Teaching materials appropriate to a child's age and developmental abilities and environmental context.
- Adequate levels of adult supervision in traffic environments.
- Frequent and regular training – there is evidence that changes in safety knowledge and observed behaviour decline with time (Duperrex, Roberts & Bunn, 2002) and, accordingly, should have a formal place in the school curriculum (Quimby, 2004).
- Parental involvement.
- School programmes that are reinforced by community safety initiatives (Quimby, 2004).

Examples of promising programmes which include most of the above elements are the training, feedback and reinforcement educational package implemented in the US (Miller, Austin & Rohn, 2004) and the large-scale programme, Kerbcraft, implemented in the UK (Thomson, 2008; Whelan, Towner, Errington & Powell, 2008). These programmes are goal-oriented and take place under supervised learning, where learners (or agents) are provided with the "free choice" in how to behave (Ghory, 2004). These educational packages also include behavioural-intervention strategies with awareness training that promotes and facilitates the acquisition of pedestrian-safety skills and behaviours (Miller, Austin & Rohn, 2004).

Work by the UK's Transport Research Laboratory (TRL) illustrates how these key elements can be combined with local culture, transport, political and

educational situations in low- and middle-income countries to develop promising child pedestrian safety education programmes. *Safe Ways*, a road safety education resource developed by the TRL, for use by primary school teachers of 10-11 year-olds, covered the following skills training topics: walking safely, observing the road environment, using protected crossings, crossing where there are no protected crossings, and choosing safe routes. *Safe Ways* attempts to teach children by involving them in the learning process and giving them real practical experience. Children exposed to the programme demonstrated an increase in knowledge and reported safe behaviour. These children's road safety knowledge and skills were further reinforced by the parental support received by parents walking their children to and from school (Sayer, Palmer, Murray & Guy, 1997). The *Safe Feet* in India followed the Ghanaian *Safe Ways* programme with similar skills training topics. This programme placed greater emphasis on improving children's observational skills in order to improve road safety awareness and thus their traffic safety behaviours (Quimby, 2004). Uganda's *In Country Training Programme* has a similar goal, which is to increase children's road safety knowledge and awareness by using the observational approach. The TRL developed a draft primary school, road-safety education curriculum and teachers guide. The whole seven years of primary education was produced in the required Ugandan format (Quimby, 2000). Proposals for the TRL to help in extending the materials available coincided with a review of the national primary curriculum (Volume 2) that took place in 2000. All three programmes drew on the local culture, transport, political and educational situation of the respective country (Quimby, 2004). Even though learning was promoted through practical experience near, but not necessarily on the roads, interactive "joyful" learning was continuously emphasised as being part of the intervention process (Quimby, 2004).

Driver education

Road safety education also includes driver education and revolves around two key issues: to raise awareness regarding the risks involved in travelling at high speed and to promote better speed management (Howard, Mooren, Nilsson, Quimby & Vadeby, 2008; Roberts, Kwan & the Cochrane Injuries Group Driver Education Reviewers). A number of driver education evaluations have been conducted in high-income countries, such as Australia, Sweden, USA and New Zealand (Hartling, Wiebe, Russell, Petruk, Spinola & Klassen, 2004; Ker, Roberts, Collier, Beyer, Bunn & Frost, 2003; Roberts, Kwan & the Cochrane Injuries Group Driver Education Reviewers, 2001). However, driver study programmes, such as the early licensing driver education programme or the post-license driver education programme, could not demonstrate a consequent reduction in road crash involvement (Hartling, Wiebe, Russell, Petruk, Spinola & Klassen, 2004; Ker, Roberts, Collier, Beyer, Bunn & Frost, 2003; Roberts, Kwan & the Cochrane Injuries Group Driver Education Reviewers, 2001).

Enforcement

Enforcement interventions refer to traffic measures that promote road user's adherence to traffic regulations, such as regulating driver behaviour and the monitoring of pedestrian behaviour (Stevenson & Sleet, 1997). Inappropriate or excessive speeds have been identified as one of the most common contributing factors in vehicle crashes (Afukaar, Antwi & Ofosu-Amaah, 2003) and pose a serious threat to the safety of child pedestrians. Therefore, the regulation of speed is important in protecting child pedestrians. As survival rates for pedestrians are much higher at impact speeds of below 30 km/h (Peden *et al.*, 2004) this speed should be the norm in residential areas, around schools and play areas. In South Africa, the speed limit is set at 60km/h on public roads in urban areas; 100km/h on public roads outside urban areas which are not freeways; and at 120km/h on freeways (Arrive Alive, 2009b).

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This suggests the need for South Africa to revisit their speed management policies to appropriately align it with those international standards which have proven to be more pedestrian safe.

However, the implementation of lower speed limits to protect child pedestrians relies on traffic law enforcement resources to ensure that limits are adhered to. Various enforcement measures are considered effective and sustainable in nature (Aeron-Thomas & Hess, 2005; Bass, 1998; Jones, Lyons, John & Palmer, 2004; Wilson, Willis, Hendrikz & Bellamy, 2006). Speed enforcement detection devices and red-light cameras are popularly used as they are considered successful and promising in reducing driver motor vehicle speeds (Aeron-Thomas & Hess, 2005; Wilson, Willis, Hendrikz & Bellamy, 2006). Even though these devices are seen as reliable in reducing motor vehicle speed and crashes, its effect in reducing child traffic injury is unclear as this aspect has not been measured. These devices' potential to reduce motor vehicle speed and crashes varies among differing countries and contexts (Wilson, Willis, Hendrikz & Bellamy, 2006), with no injury impact evaluations conducted in South Africa (Mountain, 2006).

Environmental and engineering interventions

Engineering modifications are reported to serve as the most effective means of reducing motor vehicle/pedestrian collisions (Bergman, Gray, Moffat, Simpson & Rivara, 2002). These methods are often not employed, due to the high cost and public and state neglect or indifference about pedestrian safety (Bergman, Gray, Moffat, Simpson & Rivara, 2002). There are two types of engineering measures: the engineering-environmental interventions and the engineering-design measures. Engineering-environmental measures refer to structural changes to the road or pathway environment such as pedestrian bridges and pedestrian crossings (Stevenson & Sleet, 1997), whereas engineering-

design measures refer to safety or injury-reducing products such as reflective clothing, and other visibility aids (Stevenson & Sleet, 1997).

Road design as a means to calm or separate traffic from children

Environmental interventions are directed at separating pedestrians and vehicles and reducing motor vehicle speed (Bunn, Collier, Frost, Ker, Roberts & Wentz, 2003; Von Kries, Kohne, Böhm & Von Voss, 1998). Proven and promising interventions are roadway barriers, selected traffic-calming designs, and pedestrian crossing signs used in combination with clearly marked crosswalks (Forjuoh, 2003; Stevenson, Iredell, Howat, Cross & Hall, 1999). In addition, traffic calming measures can be useful in reducing driver motor vehicle speed when visible traffic officers on roads are scarce (Stevenson, 1997).

Environmental interventions reduce children's exposure to highly congested roads and/or areas, by either providing them with safe demarcated walking pathways, or reducing the speed of adjacent traffic (Von Kries, Kohne, Böhm & Von Voss, 1998). The use of area-wide traffic schemes may further discourage motorists from using these residential roads. This is considered as useful for areas that have a high concentration of children, e.g., around schools (Bunn, Collier, Frost, Kerr, Roberts & Wentz, 2003; Schermers & Theyse, 1998). Road infrastructural changes (such as the physical segregation of pedestrians from motorised traffic) are shown to reduce the pedestrian injury risk (Tiwari, 1999). Even though speed humps are most popularly used in reducing vehicle driver speed, it is viewed as more effective when used in combination with other road design measures such as mini-circles or pedestrian crossings (Emslie, 1997a, 1997b). Traffic calming measures thus encourage speed limit compliance; it improves driver visual certainty, and improves driver capabilities and abilities to detect roadway hazards at intersections (Beyer, Pond & Ker, 2005; Roberts, 1993).

The use of visibility aids

To prevent potential collisions, pedestrians' road visibility is improved by using visibility aids (Kwan & Mapstone, 2006). Evaluations assessing the effect of visibility aids on a driver's response in preventing pedestrian-motor vehicle collisions distinguished between day and night time reflective clothing and devices (Kwan & Mapstone, 2006). Fluorescent materials in orange, red and yellow improved the pedestrian recognition in daytime, whereas lamps, flashing lights and retro-reflective materials in red and yellow are suitable for improving night-time visibility (Kwan & Mapstone, 2006). Retro-reflective materials are seen as useful for improving pedestrian visibility on the road, especially during low light conditions. Their effect on pedestrian injury risk and death is, however, unknown.

Biomotion (or biological motion) clothing and standard retro-reflective vests are equally effective in detecting a moving or stationary pedestrian in environments with high visual clutter at night (Moberley & Langham, 2002). Pedestrians often overestimate their own visibility at night, and their detection on the road by the driver is dependent on whether or not a reflective vest or biomotion clothing is worn. This design feature could serve as protection in reducing pedestrian injury and/or death (Moberley & Langham, 2002). However, for this intervention to be effective, a behavioural change is necessary on the part of the pedestrian. This will require them to practice their road safety skills with an acceptable level of appropriate road safety knowledge and awareness, and their behavioural conduct should change as well.

The use of multiple intervention types

A cluster of appropriately selected interventions commonly referred to as multi-type interventions are advocated to reduce road traffic accidents. This involves a fusion of educational programmes, enforcement, environmental and engineering

interventions. This combination of measures are considered optimal for effectively reducing child pedestrian injury and risk, its success is, however, dependent and influenced by the complexity of strategies employed (Turner, McClure, Nixon & Spinks, 2004). In addition, the amount of resources, timescales and commitment of organisations and key individuals are considered of importance to this intervention's success (Turner, McClure, Nixon & Spinks, 2004).

Community-based interventions are commonly categorised as multi-type interventions as they utilise a variety of passive and active interventions (Klassen, MacKay, Moher, Walker & Jones, 2000). The focus on behavioural change, following environmental change within the community and/or the passing or enforcement of legislation, is an attempt to alter behaviours and social norms about acceptable road safety behaviours. Generally, these types of interventions are directed, via targeted public education and behavioural modification, at children and parents, the local community and/or educators, and indirectly enforced with passive measures, such as environmental (e.g., speed humps) and enforcement (e.g., speed enforcement devices) interventions (Kendrick, 1993).

A number of effective multi-type interventions, such as the *Child Pedestrian Injury Prevention Project* (CPIPP), the *Streets Ahead on Safety* (SAOS), *Eldorado Park Project*, and the *PAVE* strategy have been reported upon. These interventions collectively produce a comprehensive and integrated intervention programme that consists of educational and/or enforcement and/or environmental intervention(s) (Cross *et al.*, 2000; Erasmus & Van Vuuren, 2004; Klassen, MacKay, Moher, Walker & Jones, 2000). These multi-type interventions are interactive and involve community participation to assist with its sustainability. They often reduce risky road behaviours on the part of the vehicle driver and

pedestrian and create safer environments (such as the setting up of playgrounds for children).

There are many economic, social and demographic factors that might influence the level of road safety and consequently, influence what is required (Lötter, 2004). Consideration must be given to the type of measure(s) and its suitability in a specific context. South Africa's National DoT has adopted an integrative approach to road traffic safety; whereas the provincial government generally promotes road safety and it initiates pedestrian safety programmes (Erasmus & Van Vuuren, 2004). However, it may be argued that some of these traffic and pedestrian safety programmes need to be more interactive, rather than informational.

CONCLUSIONS AND RECOMMENDATIONS

For South Africa, the inadequate road and pedestrian infrastructure, poor street lighting, and weak integration of transportation and land-use planning are reported to contribute to pedestrian collisions (Ribbens, Everitt & Noah, 2008). Despite national recognition of the child pedestrian injury and death burden, the ongoing and significant occurrence of these injuries suggest that the injury prevention response by existing networks, programmes and projects require support to bring about further success in reducing child pedestrian injury and/or death.

Recent international and South African research has provided initial descriptions of the child populations at risk, the typical circumstances of injury occurrence, and preventive measures (Matzopoulos, Myers & Jobanputra, 2008; Sukhai, Noah & Prinsloo, 2004; WHO, 2009); and though many interventions appears promising, there is a distinct lack of locally evaluated interventions.

Enforcement measures are amongst the most effective in low-income countries (Afukaar, Antwi & Ofosu-Amaah, 2003). Even though speed limit

enforcement by traffic police may not always be affordable, consideration of environmental interventions such as speed humps and mini-roundabouts are recommended (Afukaar, Antwi & Ofosu-Amaah, 2003; Jones, Lyons, John & Palmer, 2004). The international and, more limited, South African literature highlight the cost-effectiveness and influential role environmental approaches provide for enhancing pedestrian safety on roads. The effectiveness of educational approaches compared with environmental enforcement and even engineering interventions in promoting child pedestrian safety, is more contested. Educational measures are often not able to sustain safe street crossing behaviour, long after the intervention (Walton, Percer & Lim, 2008). The majority of child pedestrian education appears to have insufficient ability to bring about and maintain behavioural change with regards to road traffic safety.

South African researchers have emphasised community ownership as a prerequisite to ensure local road safety improvements (Vermaak, Groenewald, Makhado & Van Niekerk, 2005). There continues to be a need for increased collaborative efforts with the role players from various transport and health disciplines within the provincial departments, as well as non-governmental organisations (NGOs). There is an ongoing need for enforcement, such as the deployment required to enforce regulations. Traffic separation (such as raised-block pedestrian crossings at all schools) and speed calming measures in highly congested areas; legislation for the improved enforcement of pedestrian behaviour; the provision of ongoing instruction at scholar patrol procedures and strengthening of its programme; and the ongoing enforcement of safe drive conduct remain as important priorities for South Africa.

It is proposed that city and local road safety projects utilise government and non-governmental support,

alongside community participation required for an improved holistic approach to implement effective interventions. The purpose of this would be to allow for the valuable contribution of local knowledge on road safety issues. Essentially, active (i.e. community involvement), passive (i.e. infrastructural changes such as modifying traffic patterns) and sustainable public health interventions are best placed to bring about a safer living environment for the children in South Africa. Finally, existing interventions utilised by the South African government departments and NGOs should be assessed to demonstrate and improve their effectiveness.

Key messages

- In South Africa, child pedestrian deaths are the leading cause of injury mortality to children up to the age of 15 years.
- Road safety educational interventions yield positive child behavioural outcomes, but are more effective when used in combination with other intervention types.
- A variety of enforcement measures are considered suitable and sustainable in reducing drivers' speed.
- Environmental interventions (such as roadway barriers, selected traffic-calming designs, or pedestrian crossings) are effective in reducing children's daily exposure to highly congested roads or areas.
- Engineering design measures are more effective when used in combination with other intervention types.
- Multi-type interventions contribute to a holistic road safety strategy. These combinations are interactive and often involve community participation which assists with intervention sustainability.

REFERENCES

- Aeron-Thomas, A.S., & Hess, S. (2008). Red-light cameras for the prevention of road traffic crashes. *Cochrane Database of Systematic Reviews*, 2005 (2), DOI: 10.1002/14651858.CD003862.pub2.
- Afukaar, F.K., Antwi, P., & Ofosu-Amaah, S. (2003). Pattern of road traffic injuries in Ghana: Implications for control. *Injury Control and Safety Promotion*, 10(1-2), 69-76.
- Agran, P.F., Winn, D.G., Anderson, C.L., Tran, C., & Del Valle, C.P. (1996). The role of the physical and traffic environment in child pedestrian injuries. *Pediatrics*, 98(6), 1096-1103.
- Arrive Alive. (2009a). *Arrive Alive advertisements/value of human life*. Retrieved September 14, 2009, from <http://www.arrivealive.co.za/pages.aspx?i=25>.
- Arrive Alive. (2009b). *Speed limits and the law*. Retrieved September 14, 2009, from <http://www.arrivealive.co.za/pages.aspx?i=25>.
- Avery, J.G., & Avery, P.J. (1982). Scandinavian and Dutch lessons in childhood road traffic accident prevention. *British Medical Journal*, 285(6342), 621-626.
- Bass, D. (1998). Southern Africa (and beyond) report. *Injury Prevention*, 4(2), 161-1633.
- Bass, D., Albertyn, R., & Melis, J. (1995). Child pedestrian injuries in the Cape Metropolitan area – final results of a hospital-based study. *South African Medical Journal*, 85(2), 96-99.
- Behrens, K. (2003). *Do transport costs and tariffs shape the space-economy in the same way?* Working Paper, Economics 2003-14, LEG, Laboratoire d'Economie et de Gestion, CNRS UMR 5118, Université de Bourgogne.
- Bergman, A.B., Gray, B., Moffat, J.M., Simpson, E.S., & Rivara, F.P. (2002). Mobilizing for pedestrian safety: An experiment in community action. *Injury Prevention*, 8(4), 246-267.
- Beyer, F.R., Pond, P., & Ker, K. (2005). Street lighting for preventing road traffic injuries. *Cochrane Database of Systematic Reviews*, 2005(1), DOI: 10.1002/14651858.CD004728.
- Bishai, D., DeFrancesco, P., Mahoney, S., Guyer, B., & Gielen, A.C. (2003). How willing are parents to improve pedestrian safety in their community. *Journal of Epidemiology and Community Health*, 57(12), 951-955.
- Brisson, R. J., Wicklund, K., & Mueller, B.A. (1988). Fatal pedestrian injuries to young children: A different pattern of injury. *American Journal of Public Health*, 78(7), 793-795.
- Brodsky, H. (1993). The call for help after an injury road accident. *Accident Analysis and Prevention*, 25(2), 123-130.
- Bunn, F., Collier, T., Frost, C., Ker, K., Roberts, I., & Wentz, R. (2003). Area-wide traffic calming for the preventing traffic related injuries. *Cochrane Database of Systematic Reviews*, 2003(1), DOI: 10.1002/14651858.CD003110.
- Cross, D., Stevenson, M., Hall, M., Burns, S., Laughlin, D., Officer, J. et al. (2000). Child pedestrian injury

Pedestrian Safety

- prevention project: Student results. *Preventive Medicine*, 30(3), 179-187.
- Desimini, N., Fox, J., Geise, H., Lee, B., & Parker-Toulsen, S. (2009). *Efficacy of traffic safety programs*. School of Public Administration, University of Victoria. Retrieved September 16, 2010 from http://www.cio.gov.bc.ca/local/cio/kis/pdfs/mpa_traffic_safety.pdf.
- DiMaggio, C., Durkin, M., & Richardson, L.D. (2006). The association of light trucks and vans with paediatric pedestrian deaths. *International Journal of Injury Control and Safety Promotion*, 13(2), 95-99.
- Dunbar, G., Hill, L., & Lewis, V. (2001). Children's attentional skills and road behaviour. *Journal of Experimental Psychology: Applied*, 7(3), 227-234.
- Duperrex, O., Roberts, I., & Bunn, F. (2002). Safety education of pedestrians for injury prevention. *Cochrane Database of Systematic Reviews*, 2002(2), DOI: 10.1002/14651858.CD001531.
- Economic Commission for Europe. (2003). *Glossary of transport statistics* (3rd ed.). New York, NY, United Nations Economic and Social Council. (TRANS/WP.6/2003/6). Retrieved September 14, 2009, from <http://www.unece.org/trans/main/wp6/pdfdocs/glossen3.pdf>.
- Emslie, I. (1997a). *Design guidelines for mini-roundabouts*. Pretoria: Department of Transport.
- Emslie, I. (1997b). *Design and implementation of speed humps: Supplement to national guidelines for traffic calming*. Pretoria: Department of Transport.
- Erasmus, P., & Van Vuuren, J. (2004). *Curbing pedestrian fatalities on the African continent*. Paper presented at 17th ICTCT Workshop, 28-30 October, Estonia. Retrieved September 16, 2009, from <http://www.ictct.org>.
- Forjuoh, S.N. (2003). Traffic related injury prevention interventions for low income countries. *Injury Control & Safety Promotion*, 10(1/2), 109-118.
- Ghory, I. (2004). *Reinforcement learning in board games*. Bristol, CSTR, -04-004, Department of Computer Science. United Kingdom: Bristol. Retrieved September 14, 2010, from http://www.cs.bris.ac.uk/Publications/pub_master.jsp?pubyear=2004.
- Hartling, L., Wiebe, N., Russell K., Petruk J., Spinola, C., & Klassen, T.P. (2004). Graduated driver licensing for reducing motor vehicle crashes among young drivers. *Cochrane Database of Systematic Reviews*, 2004(2), DOI:10.1002/14651858.CD003300.pub2.
- Hobday, M.B. (2008). *The epidemiology of motor vehicle collisions involving pedestrians in eThekweni Municipality 2001 to 2006*. Unpublished Master's thesis, University of Kwazulu-Natal.
- Howard, E., Mooren, L., Nilsson, G., Quimby, A., & Vadeby, A. (2008). *Speed management: A road safety manual for decision-makers and practitioners*. Switzerland: Global Road Safety Partnership.
- Jacobsen, P., Anderson, C.A., Winn, D., Moffat, J., Agran, P., & Sarkar, S. (2000). Child pedestrian injuries on residential streets: Implications for traffic engineering. *ITE Journal on the Web, February 2000*, 71-74.
- Jones, S.J., Lyons, R.A., John, A., & Palmer, S.R. (2004). Traffic calming policy can reduce inequalities in child pedestrian injuries: database study. *Injury Prevention*, 11, 152-156.
- Kendrick, D. (1993). Prevention of pedestrian accidents. *Journal Archives of Disease in Children*, 68, 669-672.
- Ker, K., Roberts, I.G., Collier, T., Beyer, F.R., Bunn, F., & Frost, C. (2003). Post-licence driver education for the prevention of road traffic crashes. *Cochrane Database of Systematic Reviews*, 2003(3), DOI: 10.1002/14651858.CD003734.pub2.
- Klassen, T.P., MacKay, J.M., Moher, D., Walker, A., & Jones, A.L. (2000). Community-based Injury Prevention Interventions. *The Future of Children: Unintentional Injuries in Children*, 10(1), 83-110.
- Kopits, E., & Cropper, M.L. (2003). *Traffic fatalities and economic growth*. World Bank Policy Research Working Paper No. 3035. Retrieved September 14, 2010, from <http://ssrn.com>.
- Kwan, I., & Mapstone, J. (2006). Interventions for increasing pedestrian and cyclist visibility for the prevention of death and injuries. *Cochrane Database of Systematic Reviews*, 2006(4), DOI: 10.1002/14651858.CD003438.pub2.
- Lartey, G.K., Price, J.H., Telljohann, S.K., Drake, J.A., & Yingling, F. (2007). Primary grade teachers' perceptions and practices regarding pedestrian safety education. *Journal of School Health*, 77(5), 265-272.
- Lötter, H.J.S. (2004). *Road safety performance indicators for developing countries: The case for South Africa*. Stellenbosch, South Africa: CSIR.
- Mabunda, M.M., Swart, L., & Seedat, M. (2007). Magnitude and categories of pedestrian fatalities in South Africa.

Pedestrian Safety

- Accident Analysis Prevention*, 40(2), 586-593.
- MacComas, J., MacKay, M., & Pivik, J. (2002). *Cyber Psychology & Behavior*, 5(3), 185-190.
- Macpherson, A., Roberts, I. & Pless, B. (1998). Children's exposure to traffic and pedestrian injuries. *American Journal of Public Health*, 88(12), 1840-1845.
- Matzopoulos, R., Myers, J.E., & Jobanputra, R. (2008). Road traffic injury: Prioritising interventions. *South African Medical Journal*, 98(9), 692-696.
- Matzopoulos, R., Norman, R., & Bradshaw, D. (2004). The burden of injury in South Africa: Fatal injury trends and international comparisons. In S. Suffla, A. Van Niekerk & N. Duncan (Eds.), *Crime, violence and injury prevention in South Africa: Development and challenges*. Tygerberg: Medical Research Council – University of South Africa Crime, Violence and Injury Lead Programme.
- McMahon, K., Gopalakrishna, G., & Stevenson, M. (2008). Road traffic injuries. In M. Peden, K. Oyegbite, J. Ozanne-Smith, A. A Hyder, C. Branche, A.K.M. Fazlur Rahman, F. Rivara & K. Bartolomeos, (Eds.), *World report on child injury* (pp. 31-56). Switzerland: World Health Organization.
- Michon, J.A. (1981). Traffic education for young pedestrians: An introduction. *Accident Analyses and Prevention*, 13(3), 163-167.
- Miller, J.A., Austin, J., & Rohn, D. (2004). Teaching pedestrian safety skills to children. *Environment and Behavior*, 36(3), 368-385.
- Moberley, N.J., & Langham, M.P. (2002). Pedestrian conspicuity at night: Failure to observe a biological motion advantage in a high-clutter environment. *Applied Cognitive Psychology*, 16(4), 477-485.
- Montgomery, M.R. (2009). Urban poverty and health in developing countries. *Population Bulletin*, 64(2). Retrieved September 16, 2010, from <http://www.prb.org/pdf09/64.2urbanization.pdf>.
- Mountain, L. (2006). Safety cameras: Stealth tax or life savers? *Significance*, 3, 111-113.
- Muelleman, R.L., & Mueller, K. (1996). Fatal motor vehicle crashes: Variations of crash characteristics within rural regions of different population densities, *Journal of Trauma*, 41(2), 315-320.
- Museru, L.M., Leshabari, M.T., & Mbembati, N.A.A. (2002). Patterns of road traffic injuries and associated factors among school age children in Dar-es-Salaam, Tanzania. *African Safety Promotion: A Journal of Injury and Violence Prevention*, 1(1), 37-41.
- National SAFE KIDS Campaign (NSKC). *Pedestrian Injury Fact Sheet*. Washington (DC): NSKC, 2004. Retrieved October 15, 2010, from http://www.preventinjury.org/PDFs/PEDESTRIAN_INJURY.pdf
- Quimby, A. (2001). *Teaching children in developing countries to be safe road users*. Paper presented at First Road Transportation Technology Transfer Conference in Africa, Arusha, Tanzania, May 23 – 25, TRL Limited (International Division), UK.
- Quimby, A. (2004). *Teaching children in developing countries to be safe road users*. TRL Report. Crowthorne: Transport Research Laboratory.
- Peden, M. (1998). Injured adult pedestrians and the substances they abuse. *Trauma Review*, 6, 4-5.
- Peden, M., Scurfield, R., Sleet, D., Mohan, D., Hyder, A.A., Jarawan, E., & Mathers, C. (Eds.). (2004). *World report on road traffic injury prevention*. Geneva: World Health Organization.
- Pitcairn, T. K., & Edlmann, T. (2000). Individual differences in road crossing ability in young children and adults. *British Journal of Psychology*, 91(3), 391-410.
- Ribbens, H. (1997). *Pedestrian facilities in South Africa: Research and practice*. Pretoria: Department of Transport. Retrieved September 14, 2009, from <http://www.enhancements.org/download/trb/1538-002.PDF>.
- Ribbens, H. (1998). *The role of government in reducing pedestrian casualties in South Africa*. Paper presented at Thirty-Sixth Biannual Conference of the Institute of Traffic and Municipal Police Officers of South Africa, 16-18 November.
- Ribbens, H., Everitt, P., & Noah, M. (2008). Impact of an adequate road environment on the safety of non-motorised road users. In S. Suffla, A. Van Niekerk & N. Duncan (Eds.), *Crime, violence and injury prevention in South Africa: Data to action*, (pp. 48-69). Tygerberg: Medical Research Council – University of South Africa Crime, Violence and Injury Lead Programme.
- Rivara, F.P., & Barber, M. (1985). Demographic analysis of childhood pedestrian injuries. *Pediatrics*, 84(6), 375-381.
- Roberts, I., Kwan, I., & the Cochrane Injuries Group Driver Education Reviewers. (2001). School-based driver education for the prevention of traffic crashes. *Cochrane Database of Systematic Reviews*, 2001(3),

Pedestrian Safety

- DOI: 10.1002/14651858.CD003201.
- Rivara, F.P., Bergman, A.B., & Drake, C. (1989). Parental attitudes and practices toward children as pedestrians. *Pediatrics*, 84(6), 1017-1021.
- RTMC. (2007). *Interim road traffic and fatal crash report for the year 2006*. Retrieved September 15, 2009, from http://www.arrivealive.co.za/documents/27Jan2007_2006_Interim_Road_Traffic_Report.pdf
- RTMC. (2008). *Road traffic report: March 2008*. Retrieved September 14, 2009, from http://www.arrivealive.co.za/documents/March_2008_-_Road_Traffic_Report_-_March_2008.pdf
- Roberts, I.G. (1993). International trends in pedestrian injury mortality. *Journal Archives of Disease in Children*, 68(2), 190-192.
- Sayer, I.A., Palmer, C.J., Murray, G., & Guy, J. (1997). *Improving road safety education in developing countries; Ghana*. TRL Report 265. Crowthorne: Transport Research Laboratory.
- Schieber, R.A., & Thompson, N.J. (1996). Developmental risk factors for childhood pedestrian injuries. *Injury Prevention*, 2(3), 228-236.
- Schermers, G., & Theyse, M. (1998). *National guidelines for traffic calming* (Report CR-96/036.1). Limpopo: Department of Roads and Transport.
- Schieber, R., & Vesega, M. (2002). Education versus environmental countermeasures. *Injury Prevention*, 8(1), 10-11.
- Schwebel, D.C., & McClure, L.A. (2010). Using virtual reality to train children safe street-crossing skills. *Injury Prevention*, 16(1), e1-e5.
- Seedat, M., MacKenzie, S., & Mohan, D. (2006). The phenomenology of being a female pedestrian in an African and an Asian City: A qualitative investigation. *Journal of Transportation Research Part F: Psychology and Behaviour*, 9(2), 139-153.
- Simms, C.K., & Wood, D. (2009). *Pedestrian and cyclist impact: A biomechanical perspective*. New York: Springer.
- Starnes, M., & Longthorne, A. (2003). *Child pedestrian fatality rates by striking vehicle body type: A comparison of passenger cars, sport utility vehicles, pickups, and vans*. National Highway Traffic Safety Administration. DOT HS 809 640 (Traffic Safety Facts Research Note).
- Stevenson, M. (1997). Childhood pedestrian injuries: What can changes to the road environment achieve? *Australian and New Zealand Journal of Public Health*, 21(1), 33-36.
- Stevenson, M., Iredell, H., Howat, P., Cross, D., & Hall, M. (1999). Measuring community/environmental interventions: The Child Pedestrian Injury Prevention Project. *Injury Prevention*, 5, 26-30.
- Stevenson, M., & Sleet, D.A. (1997). 'Which prevention strategies for child pedestrian injuries?: A review of the literature', *International Quarterly of Community Health Education*, 16(3), 207-217.
- Sukhai, A., Noah, M., & Prinsloo, M. (2004). Road traffic injury in South Africa: An epidemiological overview for 2001. In S. Suffla, A. Van Niekerk (Eds.) and N. Duncan (Cons. Ed.), *Crime, violence and injury prevention in South Africa: Developments and challenges* (pp. 114-127). Tygerberg, Cape Town: Medical Research Council – University of South Africa, Crime, Violence and Injury Lead Programme.
- Swart, L., Laher, H., & Seedat, M. (forthcoming). *Childhood injury deaths: Urban and rural differences in South Africa*. Tygerberg, Cape Town: Medical Research Council – University of South Africa, Safety and Peace Promotion Research Unit.
- Tabibi, Z., & Pfeffer, K. (2003). Choosing a safe place to cross the road: The relationship between attention and identification of safe and dangerous road-crossing sites. *Child: Care, Health, & Development*, 29(4), 237-244.
- Tester, J.M., Rutherford, G.W., Wald, Z., & Rutherford, M.W. (2004). A matched case-control study evaluating the effectiveness of speed humps in reducing child pedestrian injuries. *American Journal of Public Health*, 94(4), 646-670.
- Thomson, J.A. (2008). *A manual for road safety professionals*. London: Department for Transport.
- Tiwari, G. (1999). *Towards a sustainable urban transport system: Planning for non-motorized vehicles in cities*. Retrieved October 14, 2009, from <http://web.iitd.ac.in/tripp/publications/papter/planning/planning%20for%20unescape.pdf>.
- Turner, C., McClure, R. Nixon, J., & Spinks, A. (2004). Community-based programmes to prevent pedestrian injuries in children 0-14 years: A systematic review. *International Journal of Injury Control and Safety Promotion*, 11(4), 231-237.
- Vermaak, L., Groenewald, K., Makhado, D., & Van

Pedestrian Safety

- Niekerk, E. (2005). *Community road safety education programmes: The South African case study*. Proceedings of the 24th Southern African Transport Conference. Pretoria, South Africa.
- Von Kries, R., Kohne, C., Böhm, O., & Von Voss, H. (1998). Road injuries in school age children: relation to environmental factors amenable to interventions. *Injury Prevention, 4*(2), 103-105.
- Walton, L., Percer, J., & Lim, E. (2008). *Pedestrian safety initiatives*. Report to the Transportation Research Board Pedestrian Safety Committee. Washington, DC: National Highway Traffic Safety Administration (NHTSA).
- Ward, H. (Ed.). (1991). *Preventing road accidents to children: The role of the NHS*. London: Health Education Authority.
- Whelan, K., Towner, E., Errington, E., & Powell, J. (2008). *Evaluation of the national child pedestrian training pilot projects*. Road Safety Research Report No.82. London: Department for Transport. Retrieved September 15, 2010, from <http://www.dft.gov.uk/pgr/roadsafety/research/rsrr/theme1/childpedestrianprojects/kerbcraftevaluationmain.pdf>.
- Whitebread, D., & Neilson, K. (1998). *Cognitive and metacognitive processes underlying the development of children's pedestrian skills*. Road Safety Research Report No. 6. London, UK: Department of the Environment, Transport and the Regions.
- Whyllie, M.A.T., & R. B. Kimball. (1997). Rural motor vehicle crashes: Can we prevent them? *Journal of Emergency Nursing, 23*(6), 542-544.
- Wilson, C., Willis, C., Hendrikz, J.K., & Bellamy, N. (2006). Speed enforcement detection devices for preventing road traffic injuries. *Cochrane Database of Systematic Reviews, 2006*(2), DOI: 10.1002/14651858.CD004607.pub2.
- World Health Organization (2005). *Violence Prevention Alliance: Building global commitment for violence prevention*. WHO: Switzerland. Retrieved May 6, 2010, from http://whqlibdoc.who.int/publications/2005/924159313X_eng.pdf
- World Health Organization (2009). *Mortality from road traffic injuries in children and young people*. Fact Sheet No. 2.1. Copenhagen: WHO regional office for Europe. Retrieved August 19, 2009, from http://www.euro.who.int/document/EHI/enhis_factsheet09_2_1.pdf.
- Wyke, S., Capleton, A.C., O'Connell, S., Duarte-Davidson, R., & Health Protection Agency. (2007). *Development of a UK children's environment and health strategy*. Oxfordshire: Health Protection Agency. Retrieved August 19, 2009, from http://www.hpa.org.uk/web/HPAwebFile/HPAweb_C/1204186222593.
- Zegeer, C., McMahon, P.J., & Burden, D. (1998). *Key engineering barriers to reducing child pedestrian injuries and deaths*. White Paper presented at Panel to Prevent Pedestrian Injuries convened by the Centers for Disease Control and Prevention and the National Highway Traffic Safety Administration, September 27-28, 1998 in Atlanta, GA and included in Chapter 4 of the conference proceedings.
- Zwerling, C. (2005). Fatal motor vehicle crashes in rural and urban areas: Decomposing rates into contributing factors. *Injury Prevention, 11*(1), 24-28.