CHILD DEATHS AND INJURIES IN DRIVEWAYS

RESPONSE TO THE RECOMMENDATIONS OF THE CHILD DEATH REVIEW TEAM

prepared for the Motor Accidents Authority of NSW

by

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EXECUTIVE SUMMARY

Background

The present report is a response to the recommendations to the Motor Accidents Authority of New South Wales by the Child Death Review Team (CDRT).

The Child Death Review Team (CDRT), in its annual report, drew attention to the deaths of 17 children who had died as a result of having been reversed over by motor vehicles on private driveways between January 1996 and June 1999. Fifteen of these children had been run over by large vehicles such as four-wheel drives and vehicles in commercial service.

The number of children non-fatally injured in this way each year in New South Wales is not known in full, because the events are not recorded in a systematic fashion, as would be the case if they had been injured in accidents on public roads. They are specifically excluded from "road accident" statistics and are not included - with the exception of fatalities in the case of the CDRT - in any other state-wide injury database.

The CDRT recommendations included public education and recommendations for examination of environmental and vehicular modifications. They were addressed to the Motor Accidents Authority of NSW because, as the government regulatory body overseeing Compulsory Third Party insurance, its interests extend to the use of registrable vehicles wherever they are used. In relation to injury coding, the CDRT made further recommendations for the attention of the NSW Health Department.

Research literature

The report includes a selective review of the literature on child pedestrian deaths, because of their relevance to the more specific issue of child hood injuries on driveways. The literature on child pedestrian injuries on public roads shows a low incidence of deaths and injury among children aged under five years, with the incidence rising rapidly after that age. The literature shows that while personal and socio-economic factors are important, it is road environmental factors that are most open to change. These include the volume and speed of traffic flow.

In contrast, the Australian and overseas literature on child injuries on private driveways shows that the incidence is by far the highest among the under five-year-olds. The issue has been identified as an important one overseas, notably in North America and New Zealand. The vehicles involved tend to be large, and have been reversing. The casualties have generally been run over, with severe crush injuries being sustained to the head and chest. The children are relatively likely to come from disadvantaged households.

1 BACKGROUND

In its 1998-1999 Report, the Child Death Review Team (CDRT), which comes under the auspices of the NSW Commission for Children and Young People, noted that since the commencement of the Child Death Register (January 1996 to June 1999), 17 children had died after being struck by a reversing motor vehicle in their own driveways.[1]

The CDRT recommended as follows:

> *The Motor Accidents Authority, in consultation with other relevant agencies, including the Roads and Traffic Authority (in particular, its Road Safety and Vehicle Standards Branches), the Institute of Early Childhood at Macquarie University, the NSW Injury Prevention Policy Unit, the NRMA, the NSW Injury Prevention Forum, the Public Health Unit of the New Children's Hospital, Westmead, and the Child Death Review Team,*
>
> - *develops targeted strategies including public education programs to reduce the number of child deaths occurring in low speed, reversal incidents on residential property*
>
> - *commissions research to determine the effectiveness of the use of refractive panels and rounded mirrors and the extent to which fenced shared driveways act as protective factors in the prevention of driveway facilities*
>
> - *upon completion of this research, if appropriate, makes a case to the Federal Office of Road Safety to cause an amendment to the Australian Vehicle Standards, particularly for vehicles in the four wheel drive and commercial categories, regarding refractive panels and rounded mirrors, and makes a case to the Australian Building Standards Board for the inclusion of a requirement for fenced shared driveways in all new multi-dwelling structures.*
>
> *NSW Health instigates a specific variation on the ICD coding system to include an additional code in inpatient collections specifically for driveway crush incidents involving motor vehicles.*

Most of the recommendations were addressed to the Motor Accidents Authority because, as the government regulatory body overseeing Compulsory Third Party insurance, its interests extend to the use of registrable vehicles wherever they are used, whether or not on the public road.

The Motor Accidents Authority of New South Wales requested the assistance of the present author in playing a coordinating role and advising on the implementation of the recommendations as they affect the work of the Authority.

Specifically, the following tasks were undertaken:

- Liaison with staff from the New Children's Hospital (NCH) in regard to hospital data;
- Liaison with NCH staff in regard to first-hand review of Child Death Review Team (CDRT) files;
- Review of the need for further and better data, and methods and costs of obtaining such data;
- Investigation of the potential for vehicle modifications, with a review of research needs and potential costs;
- Liaison with relevant agencies about incorporating recommendations into their existing programs;
- Review of the feasibility of CDRT recommendations, and suggest any potential additional or alternative strategies;
- Develop a program framework for implementation of the recommendations.

This report reviews some of the literature on child pedestrian injury and on child injuries in driveways, and goes on to discuss what new data are available in Australia. These data include information documented by the Child Death Review Team.

The report then discusses a possible framework for countermeasures and makes recommendations for a response to the CDRT proposals.

The present work was conducted under the guidance of a Reference Group established by the MAA. On the Reference Group were represented the Roads and Traffic Authority of NSW, the New Children's Hospital (Westmead), the NRMA, NSW Health, the Institute of Early Childhood at Macquarie University, the Injury Risk Management Research Centre, Kidsafe NSW, and the NSW Commission for Children and Young People.

2 PEDESTRIAN INJURY STATISTICS

2.1 Gathering statistics

The reporting of traffic accidents to police in New South Wales comes under Section 8 (3) of the Traffic Act 1909. This requires a road accident in NSW to be reported to the police when any person is killed or injured or property damage over $500 is sustained.

Traffic accident statistics recorded by authorities such as the Roads and Traffic Authority (RTA) in New South Wales are confined to those accidents which conform to the national

guidelines for reporting and classifying road vehicle accidents. The main criteria are as follows:

- the accident was reported to police;
- the accident occurred on a road open to the public;
- the accident involved at least one moving road vehicle;
- the accident involved at least one person being killed or injured or at least one vehicle being towed away.

Accidents may be recorded on either the P5 Self Reporting Collision Form or the Police P4 Traffic Collision Report. The P4 form is used when:

- a person is killed or injured;
- there was over $500 damage to property other than the vehicles involved;
- one of the parties failed to stop and take particulars;
- one or more of the drivers was reported to be under the influence of alcohol or other drugs;
- one or more of the vehicles was required to be towed away.

Overall, the RTA estimates that about 70% of accidents are reported to the police and recorded on the Police P4 report.

By definition, where a pedestrian is injured it is a matter that must be notified to police and recorded on a P4 report. In turn, the accident should be recorded by the RTA *provided it meets the other criteria for recording.* This means that some accidents will be excluded at this stage. The commonest reason for exclusion of pedestrian accidents is that they occurred on private property. Thus, as a matter of course, accidents occurring to "pedestrians" on private driveways will *not* be recorded in routine accident statistics at State, Territory or Federal level.

In practical terms, deaths and injuries that have not occurred on public roads may be sorted out of the system at several levels. Investigating police may (correctly) not log the accident they are investigating as a "road accident" because it occurred in a car park or on a private driveway. If an accident is incorrectly so recorded, it may then be sorted out by coding personnel working within Roads and Traffic Authority auspices.

Because of their extra importance, fatalities may be treated somewhat differently. All fatal reports - correctly classified or not - are faxed by the police to the RTA. These paper records do not necessarily include all deaths on driveways - strictly speaking, although regarded as being of interest, they only include those that are "incorrectly" classified as road accidents. And they are not systematically recorded or collected by either the police or the RTA. Thus, there may be information on driveway deaths in the public data system which at present is not being accessed.

The Federal Office of Road Safety, an arm of the Australian Transport Safety Bureau (ATSB), maintains a "Fatals File", which contains detailed information on all road crash fatalities in Australia. However, it does not include a single accident on private land, because these are all sorted out before the data are forwarded to the ATSB.

Although the Motor Accidents Authority maintains data on third party insurance claims, it is not at present possible to identify what accidents have occurred on private versus public land, and the term "driveways" (as for all large databases in the country) is not a searchable field.

2.2 General trends in pedestrian deaths and injuries

Nationally, pedestrian fatalities are declining in incidence, at an average of 1% annually since 1993 and at nearly 5% annually over the last five years.[2] This decline, however, generally parallels the decline in all road fatalities, indicating that it is general improvement in road safety which is affecting the figures rather than programs specifically directed towards pedestrians. In the year 1999, there were 296 pedestrians killed on Australian roads, or about one in five of all road deaths that year. This was a fall from the 1998 figure of 319 (102 in NSW). The number of pedestrians killed in 1981 was 629, or more than double the figure for 1999.

Of the 319 pedestrians killed in Australia in 1998, 42 (13%) were aged up to and including 16 years, of whom 16 were aged up to and including four years.

There is a generally similar picture for the number of pedestrians admitted to hospital over the years, with a total of 2,528 for Australia in 1997 to be compared with 3,559 in 1982.[3] The rate of reduction of reported numbers is, however, lower than for fatally injured pedestrians. In 1996, there were 66 males and 39 females (total 105) aged up to and including four years admitted to hospital in Australia.
Children aged five to 14 years are over-represented in these *road accident statistics* relative to their proportion in the population. Younger children are not, because they are relatively protected from the environment of the public street. However, a matter that still requires more data is whether their rate of *motor-vehicle-related injury* is relatively high.

3 THE LITERATURE ON CHILD PEDESTRIAN DEATHS AND INJURIES

There will often be parallels between vehicle-pedestrian collisions on public and private land that may indicate promising countermeasure approaches for the latter. Because accidents on public land and streets have been far more systematically studied over the years, they require review for the present report in order to determine whether there are any implications for accident prevention and harm reduction in accidents on private land such as driveways.

3.1 Children in road traffic

Child pedestrian issues have been isolated as a special issue for study in Australia and other countries, although the emphasis - because of their relatively high risk in traffic, on the road - is on children aged over five years. The RTA has attributed the high accident rate among five to nine-year-olds to the increasing mobility of children who may be unsupervised but who are still lacking the development of skills necessary for crossing roads safely.[4]

Child pedestrian injuries on public roadways are likely to involve older children, extending from late pre-school years into primary school. Their rates of injury on roadways far exceed those for younger children. However, wherever or however the injury occurs, it appears that younger children are at several times a higher risk of being severely injured or killed, given that collision. When small children are literally "run over" at slow speed, the injuries are often catastrophic.[5] In New Mexico, a retrospective review of children aged 0 to 14 years fatally injured by moving vehicles showed that children younger than five years experienced the highest fatality rates, which were about double the average. The relative risk for males was also about double. These small children were more likely to be crushed under the wheels of a slow-moving vehicle in both a non-traffic and traffic situation, whereas older children were more likely to have died as a result of a high-speed collision in traffic.[6]

The same pattern, whereby the smallest children tend to be injured *off* the public street and older children *on* the street, is identified in several other studies throughout the research literature.

In a comprehensive literature review of the issue, Wazana et al in Canada set out to identify modifiable risk factors for child pedestrian injuries.[7] Risk factors for child pedestrian injuries were classified as: "child", "social and cultural", "physical environment", and "driver". Risk factors within each classification were summarized and discussed. Based on 18 analytical studies, and on the magnitude and level of significance

of potential risk factors, the most important risk factors were found to come from three separate categories:

- the physical environment, specifically a high volume of traffic;
- social and cultural factors, specifically lower income;
- child factors, specifically younger age.

No studies addressed driver characteristics as risk factors. Most of the remaining significant risk factors were related to the physical environment: higher speed limits, absence of play areas, predominantly apartment zoning, lack of protection for play areas, a high proportion of kerbside parking, crowding, a high mean vehicle speed, shared driveways, risky behaviour and lack of preventive behaviours. Many of these factors are directly relevant to the prevention of driveway injuries, and will be returned to later in this report.

Careful identification of risk factors for child pedestrians is much aided by the use of case control studies, where samples of injured children are compared with children exposed to the same risk but not injured. Examples of such studies have been conducted in Australia, New Zealand and the United States.

In Perth, Western Australia, a population-based case-control study was conducted in which 40 aspects of traffic and road environment that could contribute to the likelihood of childhood pedestrian injury were examined.[8] The factors of interest were measured at 100 places where injury had occurred and 200 control sites between December 1991 and December 1993. Significant increases in the risk of injury were associated with:

- the volume of traffic (odds ratio [OR] = 2.16 for an increase of 100 vehicles per hour);
- the proportion of vehicles exceeding the speed limit (OR = 1.04) for each 1% increase in average speed;
- the presence of footpaths (OR = 11.0).

An inverse relationship was present between socioeconomic status and the odds of pedestrian injury, a relationship which has been the subject of other studies to which reference is made below. The authors concluded that these findings have obvious implications for public health, because features of the physical environment are potentially modifiable.

The same group later extended the results of the study to embrace and give more detail to other variables, and in particular to take the child's exposure to the road environment into account.[9] Altogether 100 injured and 400 uninjured child pedestrians aged 1 to 14 years were studied. Aspects of the child's social and physical environments, measures of his or her behaviour, cognitive skills, and "habitual" exposure to the road environment, as well as his or her knowledge of road safety, were recorded.

Where roads were most frequently crossed by children, the likelihood of injury increased by 12% with each 10,000 vehicles per day increase in the volume of traffic. In addition, the presence of visual obstacles on the verge of the child's street of residence increased the likelihood of injury by more than 2.6 times. In contrast, when exposure was taken into account, the *absence* of footpaths was associated with a 52% *reduction* in the likelihood of injury compared with the presence of footpaths on the child's street of residence. It was concluded that the amount of exposure to the road environment and the nature of the road environment to which the child pedestrian was exposed partly influenced the likelihood of injury in children from low socioeconomic areas, male children, and children aged 13 to 14 years. Previously, the excess incidence of childhood pedestrian injuries in these subgroups of the population had not been explained because the child's exposure per se had not been examined.

The thrust of the conclusions of this group is that while personal and socio-economic factors may be important, it is environmental factors that are the most open to change.[10] Using data from the above case-control study of childhood pedestrian injuries, another study considered the effect on public health of an environmental initiative for prevention. Population-attributable risk proportions were calculated for the variables "volume of traffic" and "visual obstacles", which had been found to predict the likelihood of pedestrian injury. The results suggest that 41% of childhood pedestrian injuries could be attributed to volumes of traffic in excess of 10,000 vehicles per week, and 20% of injuries could be attributed to visual obstacles on the street verge. It was also estimated that childhood pedestrian injuries could be reduced by up to 30% if children's exposure to roads with volumes of traffic exceeding 10,000 vehicles per week could be reduced to 15% or less. Similarly, a reduction of up to 8% could occur if visual obstacles on the roadside were reduced to 15%. In summary, in the view of this research group, it is changes to the road environment that have the greatest potential to prevent injury to children.

The effect of environmental factors on child pedestrian injury risk was also the focus of one of a series of good studies from New Zealand, conducted by the Injury Prevention Research Centre at the Department of Community Health in Auckland.[11] This was a community based case-control study. The environmental characteristics of sites of child pedestrian injury were compared with the environmental characteristics of selected comparison sites. Each comparison site was the same distance and direction from the

home of the control child as was the injury site from the home of the relevant case child. Two control sites were selected for each injury site. Cases were 190 child pedestrians aged up to and including 15 years who were killed or hospitalised after a collision with a motor vehicle on a public road during a period of just over two years. Controls were 380 children randomly sampled from the population, and frequency matched for age and sex. The risk of injury of child pedestrians was strongly associated with traffic volume: the risk of injury at sites with highest traffic volumes was 14 times greater than that at the least-busy sites, and risk increased with increasing traffic volume. High density of curb parking was also associated with an eight-fold increased risk. Risk was increased by nearly three times at sites with mean speeds over 40 km/h, although risk did not increase further with increasing speed. It was concluded that reducing traffic volumes in urban areas could significantly reduce rates of child pedestrian injury. Restricting curb parking might also be effective.

In the United States, environmental risk factors on residential streets were measured for a sample of 39 Latino children aged up to 14 years of age, and who were injured as pedestrians on a street in the same block as their home.[12] Sixty-two randomly-selected neighbourhood control subjects were matched to the case by city, age or year of birth, ethnicity, and gender. Neighbourhood assessments were performed from 3:45 pm to 5:00 pm, a fairly active time for young pedestrians. The cases were compared with the controls using conditional logistic regressions; in this study design, the odds ratios were interpreted as estimates of the incidence rate ratios.

It was found that children living in a multifamily residence had an incidence of injury three times greater than that of children living in single-family residence on a single lot. The odds ratios in the highest category were several times those in the lowest category for both parked vehicles and total number of pedestrians observed. Vehicle parking, total pedestrians, vehicular traffic volume, and speed were examined in a multivariate model. The association of vehicles parked on the street with pedestrian injury risk remained significant. Unlike the crude results, progressively greater vehicular speed was associated with a marked increase in risk. Progressively higher vehicular traffic volume was associated with a progressively lower risk. These results indicated that residential streets with a high proportion of multifamily residence, with over 50% of the curb occupied with parked vehicles, and with a large number of pedestrians observed in unenclosed areas, should receive high priority for intervention programs to reduce child pedestrian injuries. On these streets, it was concluded that measures to reduce the amount of street parking (thus increasing visibility) and reductions in vehicle speed should be considered as countermeasures for pedestrian injuries.

The role of a series of social, familial, personal, and behavioural characteristics were examined in another case-control study, this time in Canada.[13] Two hundred children aged up to 14 years injured in traffic as pedestrians or bicyclists in Montreal, Canada, were

compared with 400 uninjured children seen in the same hospitals for non-traumatic reasons. Systematic, blinded interviews and tests were conducted with parents. After adjustment for age, gender and socioeconomic area of residence, logistic regression analyses showed higher risks of injury to be related to fewer years of parents' education, a history of accident to a family member, an environment judged as unsafe, and poor parental supervision. Absence of physical health problems, fewer family preventive behaviours and reported lack of cautiousness were also related to a higher risk, whereas neither aggressiveness nor behavioural disturbance showed any such relation. These data suggested that the child's personality and behaviour were weaker risk factors for pedestrian and bicyclist injuries than were family and neighbourhood characteristics.

The above-cited studies of risk to child pedestrians on public roads all stress the importance of environmental factors and the potential for environmental change to reduce that risk. This conclusion is almost certainly as true for vehicle-child collisions on private land as it is on public streets.

The above studies also suggest that there are personal, family, socio-economic and associated variables in determining child pedestrian risk, although the authors are generally pessimistic in the ability to manipulate these variables in a way that would reduce the risk of injury. There are other published studies that explore these variables in greater depth, and which may give some indications on their importance for off-road accidents.

3.2 Children in residential driveways

The possibility that there might be a special possibility that smaller children might be at particular risk as "pedestrians", struck by motor vehicles moving on private property, appears to have first appeared in the research literature over 20 years ago. In 1979 a Canadian group set out to examine the characteristics of 452 child pedestrian fatalities.[14] The study sample was divided into three groups of victims, age 1-4, 5-7 and 8-14 years. Children aged one to four years were found to be involved disproportionately in daytime collisions occurring on or near a private driveway. Frequently, the child had been run over by a motor vehicle, which had been set in motion from a parked position. In distinction, pedestrians age 5-7 were involved disproportionately in collisions occurring in the hours immediately preceding or following school, and crossing road between parked cars. It was soon recognised that conventional police reporting of traffic accidents was not picking up a substantial proportion of these casualties, with a Baltimore study showing that under-reporting of child pedestrian accidents was in the order of 20%.[15] Later studies confirmed the extent of under-reporting of these incidents.[16]

To the end of the eighties, research on child pedestrian injuries had studied children younger than five years of age as a single group. However, in a 1991 California study, it was shown that it was the youngest children who were the group most at risk on private

driveways.[17] The authors divided children into two age groups, intended to reflect differences in behaviour and development. The study clearly demonstrated differences in the circumstances of the pedestrian injury events between toddlers (0 through two years and able to walk) and preschooler children (three- and four-year-olds). Toddlers were more likely to be injured in non-traffic events, whereas preschooler children were more frequently injured in traffic situations. A high proportion of toddler injuries occurred in residential driveways and were caused by vehicles reversing. On the other hand, the majority of preschoolers, often without supervision, were injured while crossing ("darting") mid-block on residential streets near their homes. Reflecting these differences in circumstances and also developmental differences between toddlers and preschool children, the authors considered that in order to reduce pedestrian injuries in children younger than five years of age, measures needed to be targeted to specific age groups.

By this time it was becoming clear that toddler accidents in driveways was an international problem. In 1993, all non-traffic child pedestrian deaths and injuries resulting in hospitalisation in the Auckland region over a five-year period were identified from coroner's and hospital records.[18] There were eight deaths (0.77/100,000 children per year) and 91 hospital admissions (8.7/100,000 children per year). Close to half (48%) of the non-traffic pedestrian injury admissions had been wrongly classified as traffic pedestrian injuries. Eighty-seven per cent of the non-traffic pedestrian injury deaths and 93% of the injuries occurred in residential driveways, most often involving a child run over by a reversing vehicle. The authors agreed with the limited earlier research that further studies were required to determine the most effective strategies for the prevention of non-traffic child pedestrian injuries.

Similar findings and conclusions emerged from a study in Virginia the same year.[19] The authors used alternative sources to generate their data, namely the county fire and rescue departments. It was found that between the ages of 0 and five years, non-traffic collisions account for almost 50% of all child-pedestrian motor-vehicle collisions. Accidents in commercial parking lots produced the most injuries, but home driveways produced the most fatalities.

The Auckland group then went a step further into defining the environmental contributions to child pedestrian accidents, and in particular those environmental contributors which might be open to modification.[20] A total of 103 child pedestrian injuries was identified over a one-year surveillance period. Of these, 71 per cent occurred on public roads, 24 per cent occurred in residential driveways and 4 per cent occurred in car parks. The majority of roadway injuries occurred on residential streets, and it was confirmed that driving in excess of the posted speed limit was a factor in producing injury. For driveway injuries there was no separation of the driveway from the children's play area in 75% of injury cases, the first time that this factor had been publicly identified.

In Victoria, slow-speed pedestrian non-traffic incidents to children have for some years been identified as an important cause of death to children, accounting for 14% of accidental deaths from all causes in Victorian children under five years of age between 1985 and 1995, and 12% of pedestrian deaths of all ages. In a 1997 study, the database of the Consultative Council on Obstetric and Paediatric Morbidity and Mortality was used to identify paediatric slow-speed pedestrian non-traffic-accident deaths.[21] This body has rather similar terms of reference to the NSW Child Death Review Team. Additional data relating to the car and its driver, the child, and the circumstances of the incident were abstracted from records kept by the State Coroner and the Victorian compulsory third party traffic injury insurance organisation. Twenty eight Victorian children were identified who had died in one of three types of incident (driverless cars, child interacting with the vehicle and driver, and drivers who were unaware of the child's proximity). These incidents were more common in rural areas compared with urban, and usually occurred at the child's home. The child was with or near an adult on all occasions. The vehicle was usually being driven by a relative, and was reversing in a higher proportion of "unaware" incidents compared with the "interactive" type. The association of "off-road" family vehicles and trucks with these incidents appeared to be increasing, especially in recent years. The authors suggested that countermeasures might include the separation of vehicle driveways from children's play areas, and the use of object vicinity ultrasonic warning devices for vehicles.

Age-related differences in patterns of fatal injury to child pedestrians were identified in 1988 in North America. All pedestrian vehicle collision fatalities to children less than five years of age in Washington State were evaluated for a five-year period using death certificates, coroners= reports and police records. For these very young children, unlike the pattern for older children injured in "dart-out" collisions, the child was often backed over in the home driveway by the family van or light truck driven by a parent.[22]

The issue of age-related behaviour, and implications for countermeasures, was returned to by the California group in 1994.[23] They set out to compare child pedestrian injury accidents (which they were careful to call "events") occurring in driveways and parking lots and at mid-block locations and intersections with respect to the characteristics and activity of the child, injury outcome measures, and characteristics of the vehicle and roadway. Data were obtained from hospitals and coroners during two years in an urban county, by record review and interviews. The sample consisted of 345 pedestrians 0 through 14 years of age treated for injuries at one of the participating facilities. Eleven percent of the children were injured in driveways, 8% in parking lots, 53% at mid-block, and 28% at intersections. The median age was two years for driveways, four years for parking lots, six years for mid-block, and 10 years for intersection accidents. Accidents in driveways and parking lots involved significantly more vehicles reversing, and adults were more likely to be in the vicinity of the children. Sixteen percent of those injured in driveways and parking lots

sustained head injury of moderate or greater severity, as opposed to 35% injured in the street. The authors concluded that interventions to prevent child pedestrian injuries must consider normal child behaviour as well as driver awareness as it relates to location of the events. In particular, driveway accidents involved small children, larger vehicles, and reversing.

It was the Auckland group which then performed one of the best-designed studies in this field, the intention being to put better-defined figures on the extent of risk presented by the various factors.[24] The setting was again the Auckland region of New Zealand. Cases (n = 53) were children killed or hospitalized as a result of a driveway-related pedestrian injury, in the Auckland region over a period of two years and two months. Controls (n = 159) were an age-matched random sample of the child population of the Auckland region. The absence of physical separation of the driveway from the children's play area was associated with a threefold increase in the risk of driveway-related child pedestrian injury (odds ratio = 3.50; 95%, confidence interval 1.38, 8.92%). Children living in homes with shared driveways were also at significantly increased risk (OR = 3.24; 95% CI 1.22, 8.63). The population attributable risk associated with the absence of physical separation of the driveway from the children's play area was 50.0% (95% CI 24.7, 75.3). The authors concluded that the fencing of residential driveways as a strategy for the prevention of driveway-related child pedestrian injuries was an issue that deserved further attention.

In the United States, the National Highway Traffic Safety Administration (NHTSA) had taken official notice of the driveway accident problem, and in 1996 published a note reporting on a study that NHTSA's National Center for Statistics and Analysis (NCSA) had recently completed.[25] The data were from the National Center for Health Statistics, and were intended to obtain an estimate of the number of non-occupant fatalities associated with off-road reversing accidents. Fatalities of children aged one to four years in reversing accidents were of particular focus, because it was recognised that the physical stature and comprehension level of younger children place them at greater risk in situations involving reversing motor vehicles. Off-road accidents were defined as those which occurred in locations other than public roads, for example private parking lots and residential driveways. The study confirmed that children aged one to four years were over-represented (relative to the population) in reversing accidents, particularly those occurring off-road.

Also in the USA, the Centers for Disease Control and Prevention note that how children are injured a pedestrians varies by age. Toddlers' injuries mainly result from being run over by a driver backing a vehicle in the driveway, whereas pre-schoolers injuries are typically sustained after darting out from between two parked cars on a residential street.

In the last two years the issue has been highlighted by two American studies that have received substantial publicity in that country. In a 1998 study at the Children's Hospital in

Denver, the aim was to investigate driveway-related injuries in children, identify associated risk factors, and evaluate outcome compared with other mechanisms of blunt trauma.[26] A six-year review (1991 to 1996) of paediatric (age less than 18 years) pedestrian injuries treated at two urban trauma centres was conducted: one regional pediatric trauma centre and one level I trauma centre taking children. Five hundred and twenty-seven children were identified from the trauma registry; 51 children (10%) sustained injuries as a result of being struck in their driveway. Severe injuries were typical, with children under five years of age being more likely to die (20%) than older children (none). On average, 2% of all child pedestrians died from their injuries. The figures indicated that driveway injuries carry a significant risk of head injury and a 10-fold increase in mortality in children under five years of age when compared with all other child pedestrian accidents.

Finally, in the most recently-reported (1999) United States study of the issue, the medical records of 3971 consecutive admissions to a single trauma service at a St Louis children's hospital between March 1990 and October 1994 were reviewed.[27] During this time period, 26 (0.7%) children presented with injuries sustained when motor vehicles rolled over them in residential driveways. The major objective was to determine the severity of nonfatal injuries sustained by children (less than 16 years old) when a motor vehicle rolls over them. The authors also sought to determine whether younger children (less than 24 months old) demonstrated different patterns of injury and/or a worse outcome, compared with older children. Two children died shortly after admission and were excluded from the remainder of the study. Younger children had significantly higher injury severity scores and lower paediatric trauma scale scores. Both the duration in the intensive care unit and the length of hospitalisation were significantly longer in younger children. One explanation for these observations was that younger children had a significantly higher incidence of both head and neck and extremity injury but a similar incidence and severity of chest and abdominal trauma, compared with older children.

4. NEW AUSTRALIAN DATA ON DRIVEWAY ACCIDENTS

4.1 Research Centre for Injury Studies, Flinders University

What was then the National Injury Surveillance Unit of the Australian Institute of Health and Welfare (now the Research Centre for Injury Studies, Flinders University of South Australia) published in 1997 a review of progress and current issues in child injury prevention.[28] The study used emergency department data, among which were 35 cases in which one-year-old children were struck by a vehicle. Typically, the collision occurred when a child was struck by a reversing vehicle (n=11, about 30%); ran across the road and/or into the path of an oncoming vehicle (n=10); or was in the process of crossing the road - in some cases accompanied by an adult (n=9). The resultant injuries were often severe, 60% requiring admission to hospital. The incidents involving reversing vehicles most often occurred in driveways, and occasionally in car parks. By the age of two years,

the proportion of cases involving reversing vehicles had declined to 4% and, by four years of age, no such cases were recorded.

4.2 Child Death Review Team

The stimulus for the present report, as noted at the beginning, was the publication of the report of the Child Death Review Team, which reviews all child deaths in NSW.

The CDRT report itself gave only an outline of the circumstances surrounding the child deaths on driveways. It noted that since the commencement of the Child Death Register (that is, for the period January 1996 to June 1999), 17 children had died in New South Wales after being reversed over on driveways at their homes. Of these 17 children, 15 children (including 13 toddlers) were run over by four-wheel drive or large commercial vehicles.

In 1998-1999, five toddlers (three males and two females) aged between eight months and three years were run over in their home driveways. In three of these incidents the vehicles were large with poor visibility (presumably this is means visibility to the rear). In 1997-1998, four toddlers (two to four years old) and two older children were killed on residential property when reversed over by four-wheel drive or large commercial vehicles. In 1996-1997, six toddlers (aged from 14 months to three years) were run over in their home driveway by such vehicles.

In order to glean more information from the base data available to the CDRT, it was intended that a visit would be made to the premises of the team in order to study the original files. Unfortunately, it proved impossible (for reasons of absolute case confidentiality) to obtain access to these files, so that the detail - particularly in regard to vehicle types and accident location - that would have been useful in filling out the picture presented in their report was unobtainable.

Another avenue for getting exactly the same information is through coroners' records. These were probably the basis of the CDRT review. NSW coroners' records may already be made available through a process of submission and approval. However, the system will soon change, as a result of the National Coronial Information System coming on line. The State and Territory Attorneys General have endorsed the system, which means that at a time shortly in the future, for the payment of a fee, "outside" organisations will have access to the national coronial database. The location "driveway" is not and will not be a specific field in the database (it is now too late to suggest any changes), but the word can be searched for in narrative accounts. Also, the numbers are not so large that they would preclude a search for "home" deaths among the relevant age group.

4.3 The New Children's Hospital, Westmead

The Child Death Review Team noted in its report figures from the New Children's Hospital, Westmead, indicating that between March 1996 and December 1998 32 children were admitted to that hospital alone having been severely injured when reversed over, usually by a parent, family member or friend.

There has been a recent but as yet unpublished review of driveway-related injuries to children aged under 16 years admitted to the New Children's Hospital between November 1995 and February 2000, as well as deaths reported to the NSW Paediatric Trauma Death Registry between January 1988 and December 1999.[29] It is reported that 42 children were admitted to the hospital in the period of just over four years, and 14 deaths were reported to the Registry over 12 years. These figures represent around 10% of all paediatric pedestrian injuries and deaths, a proportion which is within the order of magnitude of that reported in the overseas literature described above.

In addition, as part of the present project, New Children's Hospital Emergency Department attendance records were searched for reference to driveways in narrative text, and several more children were identified as having been injured on private driveways but not admitted. This is probably not a complete record of all children attending after accidents on driveways (as confirmed by the research on admissions cited above), because the location had to be identified as such in order to be identified in the database search. However, the numbers recorded have increased each year, probably because of an increased awareness of this problem among Emergency Department staff. There are 23 listed in the Emergency Department database from 1996 to 1999. Thirteen were admitted. Twenty were aged four years or less and 14 were male. The types of injury could be generally divided into head and lower limb injuries, with head injuries more likely to be admitted. The driveways were almost all at the child's home or a neighbour's.

4.4 Liverpool Hospital

The South Western Sydney Area Health Service (SWSAHS) has a busy trauma service, and as part of this project interrogated its trauma registry for child pedestrians who were injured at home. (The words "home" and "vehicle" were used as keywords.)

In the 1995-1999 registry there were records for 101 child pedestrians, aged 0 to nine years, in the "major injury" category. Of these, 15 were coded as having occurred at home, and one of these died. Twelve of the 15 were aged one or two years, and so are most likely to have been injured on a home driveway. However, only three of these had a text description confirming that this was the case.

4.5 Other data sources

Because claims under the Compulsory Third Party scheme in New South Wales may be made following accidents involving *registrable* vehicles, whether on private or public property, it may well be that over the years a body of such claims may be built up and scanned. A few such claims submitted to NRMA Insurance Limited have been reviewed, although they are not collected in a systematic manner. They confirm the prevalence of very small children and station wagons.

5 TOWARDS A COUNTERMEASURE FRAMEWORK

5.1 Definition of a model approach

The reduction of child pedestrian death and injury is an exceedingly complex endeavour, requiring a multidisciplinary and multifaceted approach across several different fields, addressing human behaviour, environmental design and modification, and vehicle design and equipment.

The specific issue of child deaths and injuries in driveways is an identifiable subset of the wider problem. Compared to child pedestrian injuries generally, it is an easier problem to address because the location is strictly constrained, the pattern of injury causation - reversing vehicles running over the children - is quite narrowly defined, and the ages of the children mostly affected are in the toddler category.

It is, however, in many ways a harder problem to address because the mass epidemiological data are poorly defined. Thus, the *risk* associated with specific behaviours, vehicles and environments is not clearly identified. This makes it difficult to develop a program that is founded on a sound theoretical model for the injury control problem and factors in which interventions can be based. Further, driveway injury reporting systems are insufficiently developed to allow the collection of adequate data and the use of meaningful analysis to either predict or to evaluate changes in the present situation.

It is also harder because there is no clearly defined public accountability for addressing the problem. Child pedestrian deaths and injuries occur off the public road and are therefore not addressed by the Police Service and the Roads and Traffic Authority in the systematic manner that would be the case for, say, child pedestrian "dart-out" accidents.

Nevertheless, there is ample justification for addressing the issue. In round figures the number of child deaths and injuries on driveways is probably about 10% of all child pedestrian deaths and injuries. In terms of pure numbers, such figures make child deaths and injuries in New South Wales associated with school bus transport look insignificant,

yet the latter are the subject of substantial countermeasure activity and attract considerable allocation of public resources. For example, after two students were injured as a result of having been trapped between the leaves of closing bus doors, the door systems of all buses were modified by regulation soon afterwards.

Appropriate models for injury control include those proposed by Haddon (a matrix of interactions between humans, vehicles and the environment, and pre-event, event and post-event phases), and the PRECEDE-PROCEED model.*

The PRECEDE model is a framework for the process of systematic development and evaluation of health education programs.[30] Appropriate health education is considered to be the intervention (treatment) for a properly diagnosed problem in a target population. The model recognises that health and health behaviours have multiple causes that must be evaluated in order to assure appropriate intervention. PROCEED was added to the model in the late 1980s in recognition of the emergence of and need for health promotion interventions that go beyond traditional educational approaches to changing unhealthy ("unsafe", in the present context) behaviours. First, there is planning to "precede" implementation. There follows the move to "proceed" to promote the plan or policy, regulate the environment, and organize the resources and services, as required by the plan or policy.

The Centre for Health Promotion and Research at the School of Public Health at Curtin University has proposed some minor modifications to the PRECEDE-PROCEED model, as it might be applied for the prevention of injury to child pedestrians.[31] Their adaptation of the model is incorporated in the following outline of the principles adopted by the Centre, and which in many ways are appropriate for reducing child injuries on driveways.

Step 1: Epidemiological factor assessment.

This involves identifying the epidemiological details of the problem and the characteristics of the groups at risk. The information is used to help define target groups.

For the prevention of child injuries in driveways, the data in the literature and the data newly emerging are the only data available. It may be possible to produce better data in the future. As it is, however, the data presently available are only

* PRECEDE is an acronym for Predisposing, Reinforcing, Enabling, Causes in, Educational Diagnosis and Evaluation.

PROCEED is an acronym for Policy, Regulatory, Organizational Constructs in Educational and Environmental Development.

just sufficient to outline a general framework for injury prevention. As presented in more detail later in this report, countermeasures such as behaviour change will have to be integrated with other measures such as safer housing and general child injury prevention programs.

On the basis of the epidemiological data presently available, it appears that the primary *human* target for intervention programs is pre-school children (under five years old) and their parents, with older children being regarded as a secondary target and probably requiring different measures.

Available epidemiological data also indicate that the primary *environmental* target is the private driveway, with associated targets being public authorities and private residential planners and architects.

There are also *vehicles* to be targeted. These are primarily large vehicles, including four-wheel drives and other vehicles with poor vision to the rear.

Step 2: Behavioural and environmental assessment.

In this phase, behavioural and environmental factors are considered as risk factors, and the expected changes identified. Risk factors and behavioural objectives for children on roads may be identified as inappropriate road crossing and failure to seek help. For parents, failure to supervise, poor instructions and poor modelling behaviour have been identified. Environmental assessment has identified traffic volume and speed, road design and roadside obstacles, as noted in the above literature review.

Few of these factors are relevant to the problem of child pedestrian injuries in driveways. Further, the *extent* of change to be expected from interventions aimed at driveway injuries has never been clearly assessed in previous research, but only the *type* of suggested change (fencing driveways, for example).

Step 3: Contributing factors assessment.

In the PRECEDE-PROCEED model, contributing factors are classified into "predisposing", "enabling" and "reinforcing factors". *Predisposing* factors provide motivations for actions: knowledge, attitudes and beliefs, for example. Very few people know that child vehicle injury in private driveways is any problem at all, which means no motivation for action exists at all. *Enabling* factors make it possible for motivation to be realised, such as resource availability and behavioural skills. Both may be limited in some households. *Reinforcing* factors provide incentives for continuing desirable behaviours, and include social and peer

influence, professional and mass media education, and perceived rewards. It will be an important aim of countermeasures for driveway injuries to provide such reinforcement through a variety of channels.

Step 4: Intervention strategy selection.

For this step, once factors have been identified quite specifically, intervention strategies can be selected. The Curtin group identified both educational and environmental approaches, which may be used in combination. Particularly because of the young age of so many of the children injured in driveways, the importance of combining all approaches - behavioural, environmental and vehicular - is highlighted.

The PRECEDE-PROCEED model provides a useful check list of factors and approaches. For the purpose of the present report, risk factors will now be discussed under human, environmental and vehicle headings, with integrated consideration of contributing factors and strategy identification. The selection of strategies is then more generally discussed in a following section of the report.

5.2 Human behavioural factors

The epidemiological data clearly show that the primary target for countermeasures to driveway injuries should be very small children, aged under five years. Thirteen out of the 17 children (76%) in the CDRT series of fatal injuries were four years or younger. The vast majority of children injured on driveways in the South Australia (NISU) study were aged one or two years. Thirteen out of the 15 child pedestrians (87%) in the SWSAHS Regional Trauma Registry were aged four years or younger, and the other two were aged five and six. Twenty out of 23 children (87%) recorded as attending the New Children=s Hospital Emergency Department after driveway accidents were aged four years or under; in the other three cases the vehicle had simply run over the child' s foot and none were admitted.

Given that under-five year olds are at greater risk, are there then any ways to modify behaviours among the group in order to reduce this risk?

Children learn mostly by observing and imitation. Examples set by parents can have long-lasting effects on the behaviour of their very small children, potentially with a beneficial influence that extends into the road-using years.

There are of course social and cultural risk factors to be taken into account in this context. For child pedestrian injuries, many studies have shown that children from families of low socio-economic status are at higher risk, and this is likely to be so for non-traffic injuries.

Mothers of injured children are more likely to be younger, less educated, and working. Other studies have shown crowding in houses to be a factor: the Auckland group have shown that children from homes with three or more children in the family are three to four *times* more likely to be injured than those from homes with two or fewer children.

Families of injured children are much less likely to practice preventive behaviours, to provide good supervision and be quicker to discontinue good supervision.[32] A family history of previous injury is therefore an understandable risk factor.

Of the above risk factors, probably the only one that is open to direct modification is preventive behaviour. For this, education must be targeted at parents through any available avenues.

The systematic review by Wazana et al[6] of intervention studies aimed at reducing child pedestrian injuries - and which included control groups - found significant reductions in injury rates following educational interventions, but these were all aimed at kindergarten and older school children. The reviewer was sceptical about the results, suggesting a degree of positive publication bias.[33] However, behavioural researchers such as Barry Elliott (personal communication) point to the work of educational theorists who are arguing that it is never to early to help children develop road-use skills, even if the likelihood of success is low until the age of about four years. For this very early age group, parents and carers must be intimately involved, with families being brought together with education professionals. Safety in the traffic environment can be a unifying influence in such moves.

Local communities in New South Wales have access to childcare services for young children where parents, children and staff can interact in an environment that encourages the interchange of information and ideas. Through these centres, parents can be helped to identify risks and transmit relevant messages to children. Parents can come to understand that children do not process risk-related information they way they do. Children may see - for example, a reversing light - but they do not perceive and process the information in a way that means danger to them. Adults must come to understand the children' s point of view. "Early Childhood Centres", which were previously known as Baby Health Centres, provide support and care to mothers and babies up to the age of five years. "Early Childhood Education Centres" embrace a generic term given to children' s services such as pre-school centres, long day care centres and kindergartens. Both types of service can provide educational support for families on a range of health and safety issues. Working with early childhood services is a logical approach to improving the safety of children near driveways.

A key to the achievement of such aims in New South Wales is the partnership between the NSW Roads and Traffic Authority (RTA), as the lead authority for road safety in NSW

and the Institute of Early Childhood at Macquarie University, the major provider of early childhood teacher education in NSW. To quote from the web site of the University's Early Childhood Road Safety Education Program (www.iec.mq.edu.au/childroadsafety):

> *The mission of the Program is to improve child safety in the real traffic environment in the short term and develop safe community attitudes to road use in the long term. For those working in the Program this means:*
>
> - *increasing the awareness of the need for road safety education of young children;*
> - *fostering developmentally appropriate practice on the delivery of road safety education by children's services staff and by students in early childhood tertiary education programs (i.e. Universities, TAFE Colleges and other Accredited Training Providers);*
> - *ensuring that consistent road safety messages are provided to young children and their families, and to the professionals who work with them;*
> - *being responsive to the needs of local communities;*
> - *establishing and maintaining partnerships with existing community networks to advocate for early childhood road safety education.*

The program has adopted a series of philosophical guidelines, as follows:

- *responding to individual differences in the developmental pathways of young children;*
- *acknowledging and supporting the different learning styles of young children;*
- *supporting the establishment of partnerships with families;*
- *recognising the uniqueness of local communities; and*
- *respecting social and cultural diversity.*

The Early Childhood Road Safety Education Program provides professional development workshops for early childhood services, community outreach and resources to foster developmentally appropriate practice in the delivery of road safety education. Information which supports effective early childhood road safety education and research is

disseminated via each of these roles. The program is increasingly working together with Local Government Road Safety Officers (RSOs).

The program provides a number of free workshops to all early childhood educators. Those most specific to the present project are the following two.

> "Road Safety and the Under 3s" is a workshop which considers child development, particularly for the 0-3's age group, and consequent implications for road safety. The workshop also explores strategies for building partnerships with families and incorporating this perspective in planning for road safety education within infant and toddler programs.
>
> "Road Safety for Family Day Care" is a workshop which is specifically designed for Family Day Care carers and includes opportunities to review and discuss road safety education issues relevant to them. The workshop also reviews strategies for building partnerships with families and ideas for programming for road safety education.

Other workshops cover more general overview topics, working with families, and policy development.

Some of the activities of the program specifically address the issue of safety in the "traffic" but "off-road" environment. For example, in a published Fact Sheet - *Key Road Safety Messages for Adults Responsible for the Safety of Children As Pedestrians* - it is noted that the road traffic environment includes carparks, footpaths, roads, unfenced front yards and driveways. Figure 1 shows a series of photographs published in the Centre' s *Gazette - Kids and Traffic*, which make the point graphically.

In the United States, the Centers for Disease Control and Prevention transmit similar messages. For example:

- Supervise young children and do not leave them alone to play, especially near a street or the driveway.

- Make sure that the children=s play area is at least 200 feet from any dangerous area (such as a street, driveway, a vacant lot, or water). If it is within 200 feet, the play area should be fenced.

Kidsafe New South Wales has "Kidsafe House" on the premises of the New Children' s Hospital in Westmead. Kidsafe House is a safety demonstration house that looks like a typical family home, with special design features. The information and displays are relevant for parents, grandparents, students, child care workers and their supervisors. The

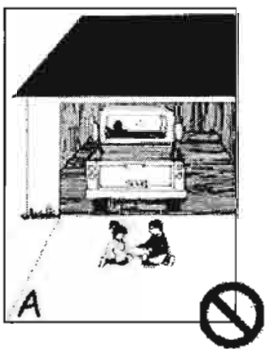
house features displays on hot water scalds, locks, poisons, finger jams, nursery furniture, choking, falls and lounge room settings. There is also a safe play area with lots of ideas on safe design and creative spaces. There is no display or information specifically on driveway injuries, but perhaps in association with the work of the very active and innovative Playground Advisory Unit, this could probably quite easily be incorporated. There is now an emerging opportunity for Kidsafe to take up this issue at a national level.


When are children at risk as pedestrians?
Where are children at risk as pedestrians?
Watch out! There's a car about!
kids and traffic gazette
Issue 1, 2000

Figure 2

Tip #10 play it safe: walking and biking safely(toddlers & preschoolers)
Dangers for young children on the move: darting out into traffic from the middle of the block; playing in or near the street; riding a tricycle or bike in a parking lot, driveway, or street.

Young children are NOT small adults! 1. They move quickly and can run into the street without warning. 2. They don't know safety rules and expect adults to watch out for them. 3. They are small and hard for drivers to see. 4. They cannot judge speed or distance of vehicles moving toward them.



A typical approach of an overseas administration is that of the US Department of Transportation's National Highway Traffic Safety Administration (NHTSA) is exemplified in the "Tip Sheet" reproduced as Figure 2 (with references to bicycle safety omitted). There is a clear recognition of the danger represented by driveways in this material, which is intended for the attention of parents.

In the longer term, attention can be paid to those factors that are less open to modification, such as socio-economic status, crowding, working status, education and so on. The implications for community well-being in these factors extend, of course, well beyond the boundaries of risk reduction in driveways, but there may be some families for whom a high risk is identifiable.

Children hit by cars can be hurt or killed, even when cars are moving slowly. Toddlers (one and two year olds) are most often hurt by a backing vehicle. If a child is playing in a driveway or parking area (**A**), a driver may not see him. Preschoolers (three and four year olds) are most often hit when dashing across a street near home.

Falls from tricycles or other play vehicles can cause serious head and brain injury. These injuries to young children can be as serious as injuries to older children falling from bikes.

Take steps to safety

Supervise, supervise, supervise Parents and caregivers must watch toddlers and preschoolers closely when they are near parked or moving vehicles. To supervise properly, you must be near your child, not watching from a distance. Hold your child's hand when you walk together along the street (**B**).

Find safe places to play Keep children away from traffic (C). Fenced yards, parks, or playgrounds are good places for your child to ride and play.

Are there safe play places for children in your neighborhood? If not, talk with neighbors, local police, and community planners about ways to improve the area. (See Tip 14.)

Set a safe example Young children learn by watching adults. Show them safe ways to cross streets and always wear a helmet when you ride a bike.

Get them in the habit When walking, talk to your child about street safety. Show him/her how to stop at the edge of the street and look for cars. Don't expect your young child to do this by herself.

Start children wearing helmets with their first tricycles or play vehicles. When children begin helmet use early, they are more likely to keep the habit in later years.

5.3 Environmental factors in driveway injuries

5.3.1 Standards and regulations

Risk factors associated with the physical environment are usually directly modifiable. In particular, the importance of physically separating the child's dwelling place from the driveway environment by way, for example, of fencing is identified in several of the research projects reviewed above.

The CDRT report drew attention to what it referred to as the "Australian Building Standards Board", in the context of a possible requirement for fenced shared driveways in all new multi-dwelling structures. The organisation referred to is in fact the "*Australian Building Codes Board*". This is a joint initiative of all levels of Government in Australia, intended to provide for efficiency and cost effectiveness in the design, construction and use of buildings through the creation of nationally consistent building codes, standards, regulatory requirements and regulatory systems.. The Board produces and maintains the "Building Code of Australia" (BCA), which has been adopted into building regulation by all States and Territories. It covers technical provisions for the design and construction of buildings and other structures, covering such matters as structure, fire resistance, access and egress, fire-fighting equipment, mechanical ventilation, lift installations and certain aspects of health and amenity.

The BCA is not only aimed towards public buildings and their structure, but also towards private dwellings, driveways and other modes of access. Private dwellings are provided for in Volume Two (Housing Provisions) of the BCA, and the standards are presented in plain English to assist users in understanding the requirements of the code.

The BCA is being written into a performance-based code, following consideration of numerous overseas models. For the development of new codes, the first step under these performance-based standards is to define the reason the community wants a matter regulated, usually referring to the need to safeguard people. While such requirements currently refer to details such as the height of a room or space, there is nothing in the BCA as written which would prevent attention being drawn to need for physical separation of driveways from dwellings. There is no obligation to adopt any particular design or construction method, but only to comply with the relevant performance standard. Innovation and the use of new technology are encouraged.

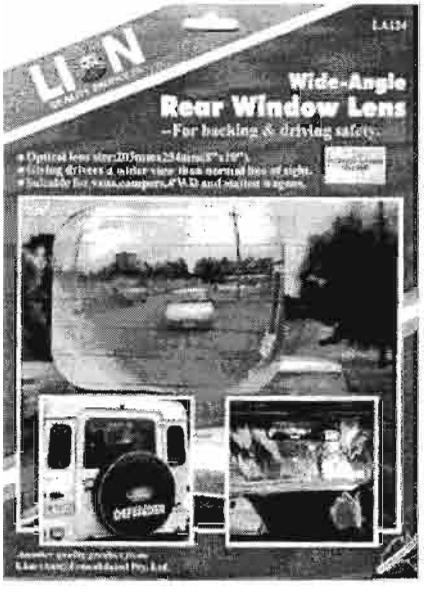
The BCA is brought into operation by enabling building regulatory legislation in each State, so that the legislation can call up the BCA to fulfil technical requirements which have to be satisfied in order to gain approval of a building proposal.

The matter of driveway protection would certainly seem to be one that could be brought to the attention of the Australian Building Codes Board, for consideration for incorporation into the BCA. The RTA has as a component of its road safety strategy "*improved management of the level of pedestrian/vehicle conflict to provide greater safety and amenity for pedestrians*", with strategies including the marketing to local government of traffic management schemes which reduce potential pedestrian/vehicle conflicts.[34]

Local councils have influence on local planning and building regulations. However, in matters of any detail such as driveways, including set-back of dwellings from the road - let alone newly emerging issues such as limiting access to driveways from the dwellings - councils make many of their own rules and take very much their own decisions A joint approach by the RTA and the MAA to the Local Government Association on the issue of driveway injuries could well be fruitful.

5.3.2 Voluntary measures

There is no obstacle, of course, to parents and other householders voluntarily applying sensible protective measures to their own driveways, when small children may be at risk in their locality. Long before swimming pool fencing legislation became applied, a substantial proportion of householders responded to the risk of toddler drowning once they understood the scale of that risk, and undertook their own protective measures.



"Public education" may help to transmit understanding of the risks reflected in the use of driveways, but it is probable that such education will be far more effective if it is undertaken at the local level. This can be done quite economically, by using networks such as those already established by Road Safety Officers, Early Childhood Centres and the like.

Figure 3

5.4 Vehicle engineering and technological factors

5.4.1 Visual warnings

5.4.1.1 Mirrors and lenses

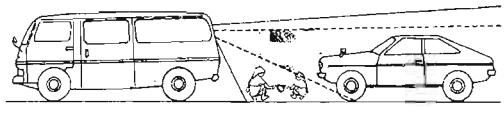
As reiterated in this report in several sections, a highly important factor in collisions where a vehicle has reversed into a child is the size and configuration of that vehicle. The kinds of vehicles identified in local studies as having characteristics predisposing to these accidents are four-wheel drive passenger cars and light commercial vans. Both have very poor visibility to the rear, particularly for objects relatively close to the vehicle.

This problem has been widely recognised, although not widely publicised. Subaru is perhaps the only vehicle manufacturer that has put that recognition into practice by having an internal company standard that minimises the blind spot by defining the uppermost point of the centre of the rear window. The shallow "V" along the bottom of the rear window of the Subaru Liberty range of station wagons is a demonstration of this.

A cheap and quite effective measure for any vehicle owner is to fit a Fresnel lens to the rear window. This blurs the image slightly, but does extend the field of view downwards. These lenses are on the market as the *"Wide-Angle Rear Window Lens"*, marketed in Australia by Lion Products (who also market a wide range of vehicle rear-view mirrors). The price at motoring accessory outlets is about $25.00. Figure 3 shows the packaging, and Figure 4 shows the increase claimed in the field of view, which is verifiable in practice.

The use of these lenses is quite widespread among the light commercial fleet, but they have never been marketed strongly to users of suburban four-wheel drives. This is an opening for an initiative by many of the stakeholders in the present project. For example, Kidsafe NSW could bundle such an item along with other child safety gadgetry promoted by this organisation.

A few light school buses and similar vehicles have been fitted with a second mirror, above the rear of the vehicle, which can be viewed through the normal rear-view mirror and which gives a view directly down behind the vehicle.



Figur 4

5.4.1.2 Video equipment

Soon to be seen on new passenger vehicles is a far wider use of video cameras, facing to the rear with the image on a screen within the driver=s field of view. They are already widely used in commercial transport, and especially tourist buses. The Kenworth Truck Company will soon offer video cameras for rear vision as optional extras. They can certainly be fitted in such a way that gives a view of a child just behind a vehicle. A vehicle just introduced by Honda in Japan, and intended for the American and Asia-Pacific markets (possibly including Australia) is the Avancier, which is a high-mounted station wagon based on the Accord "chassis" platform. An option for this vehicle will be a closed circuit television camera on the rear hatch that shows the area immediately behind the vehicle, intended primarily to assist the driver when reversing in a tight space. Another option is an ultrasonic transmitter system to warn of obstacles immediately in front of and behind the vehicle, of a kind discussed further below.

Britax is a company that operates in Australia, and is well known for its involvement with Safe-N-Sound in the manufacture and sale of child restraints. Another division of the company is Britax Rear Vision Systems, which is primarily a manufacturer of vehicle mirrors but is also developing a number of new features for its technology. These include what the company refers to as "near-object/blind-spot detection" systems and camera technology.[35] The rationale for this work is that this technology can make a major contribution to vehicle aerodynamics, rather than safety, but that is no reason not to seek other virtues. The company states: *"Some vehicles already have near-object detection technologies, but this will only become commonplace if the market demands it".*

The present project could generate some of this market demand. There is a clear public interest in this issue, just as there is public and official interest in new – "intelligent" - vehicle technologies. The data presented in the present report is sufficiently focussed to persuade both manufacturers and consumers that the use of these emerging technologies to prevent childhood driveway injuries is justifiable on commercial as well as public interest grounds. Some other technologies are discussed in the following section.

5.4.2 Near-object detection systems

Sensing the proximity of other vehicles is a field of intense research associated with the concept of Intelligent Transport Systems (ITS). Such sensing is fundamental to devices such as "intelligent" cruise control systems, which maintain a set distance behind the vehicle ahead, and collision avoidance systems, which warn the driver or even over-rides the driver=s control having sensed that collision is going to occur (see Figure 5). Some of this technology is deliberately being adapted to near-object detection.

The best known of these, and in the market in Australia as original equipment in some luxury cars, are sensors primarily aimed at making parking easier. Mercedes Benz have on their S-Series models what they refer to as the "Parktronic System". This is a system using ultrasonic sensors, a control unit, visual display elements, and a speaker for an audible warning.

The Parktronic system operates on the echo sounder principle. Using ultrasonic signals which are registered by sensors located in the front and rear bumpers the electronic control unit calculates the distance between the car and an obstacle. When reversing the system monitors both the front and rear, while only the front is monitored when moving forwards. The system is active within a speed range up to about 15 km/h. It monitors the front end within a distance range between 15 and 80 cm, and the rear end within a distance range between 20 and 120 cm. As soon as an obstacle is detected within these areas the visual and audible warning elements are activated. Depending on the distance from the obstacle the visual signals are activated first. When the distance becomes less than about 35 cm the audible warning sounds intermittently, followed by an uninterrupted sound when a distance of about 20 cm is reached.

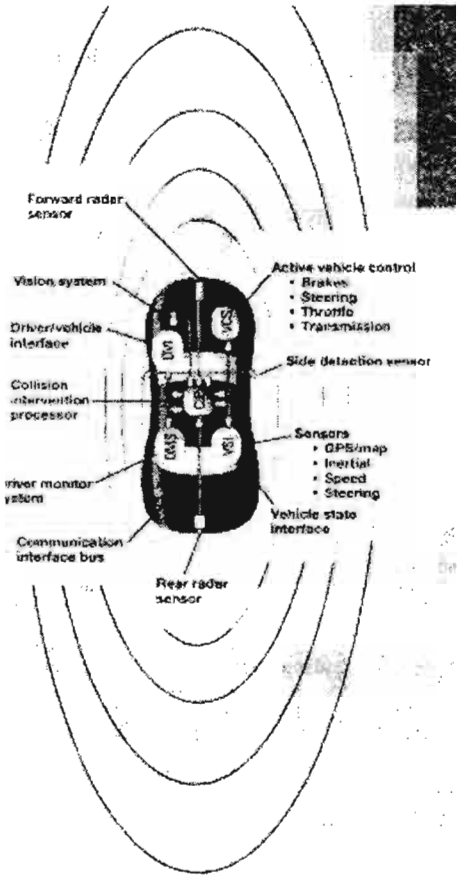
The company claims the following benefits:

- it facilitates precise parking
- it makes parking easier even in tight situations;
- it effectively helps to prevent parking damage.

Discussion with company executives confirms that the system will probably pick up small children and warn the driver of their presence, but making the claim that this is so is something they cannot do at present.

BMW have a similar system, called "Rear Park Distance Control", which the company claims is to make lining-up and parking the car much easier. An acoustic signal warns of obstacles detected from 1.5 metres, thus reducing the chance of injury or damage. Discussion with a senior engineering executive of the company again confirms that the system would probably pick up the presence of a child. However, to guarantee that this occurred would mean that the system would have to be set to a very sensitive level, which in many driveways would lead to the transmission of too many false alarms, which could lead to a false sense of security.

Other companies are coming into the market with new cars in mind, with parking aid the major marketing tool. Delphi are one of the biggest companies in the automotive industry, to which they can supply a complete package of sensors (see Figure 5).



Figur 5

A very new market is emerging in the United States for the supply of after-market equipment which will perform the functions of parking aids and near-object detection systems. Some have collision with children specifically in mind. One such manufacturer is Sense Technologies, a Canadian company which manufactures and markets the *"Guardian Backup System"* for existing motor vehicles.

This company clearly recognises the toddler problem, referring to U.S. Department of Transportation estimates that there are approximately 390 fatalities caused by slow speed rearward moving vehicle accidents, and that as many as 40% of these fatalities are children under the age of four. Company literature states: *"These children are inadvertently caught in a dangerous situation and unable to cry out a warning, are subsequently run over, and in many cases, by a loved one. Consequently, not only does one suffer the loss of a child, but must also endure the debilitating, emotional and psychological trauma caused by knowing their actions resulted in the death of a loved one. It is easy to recognize and understand the cost effectiveness of the Guardian™ system."* [36]

The patented system alerts drivers to obstacles behind them when the vehicle is in reverse. The company claims that the advantage of the Guardian over other systems on the market is that its microwave radar technology works in all adverse weather conditions (where a camera, for example, might be rendered ineffective). The system warns the operator of the vehicle if there are obstacles in a predefined area behind a vehicle when the vehicle is engaged in reverse. In the event of an imminent rearward collision, an audio and visual warning will alert the operator inside the operator's compartment, triggered only in the event of a problem.

The system is comprised of a transceiver, an antenna, an intermediate frequency amplifier, and an audio/visual alarm. The unit is adapted for mounting at the rear of the vehicle, thereby directing its microwave output to the rear of the vehicle. It is about the size of a pack of cigarettes and is easily installed.

It employs a microwave radar technology that applies the Doppler shift principle to detect the presence of a moving target within a predefined area behind a vehicle. Continuous microwave signals are projected by the transceiver rearward and return microwave signals are reflected from any object within the transceiver range and supplied back to the transceiver through an antenna. An object that moves closer to the unit, due either to the movement of the object itself or the rearward motion of the vehicle, sends back a signal that is shifted slightly in frequency. The resultant Doppler shift signal triggers the system and its amplification drives the audio alarm. A visual display giving an indication as to relative distance from the detected object is located inside the vehicle where it can be conveniently observed by the driver. The effective range of the system is adjusted to accommodate the needs of different-sized vehicles and for blind-area coverage.

When the driver places the vehicle in reverse, a green light appears indicating that the unit is in working order. When the vehicle moves and the sensor detects an obstruction in the zone from two to three metres behind it, a green light and a yellow light begin alternately flashing while an audible alarm sounds intermittently. If the sensor detects an obstruction in the zone from one to two metres behind it, a green light and a red light begin alternately flashing and the audible alarm sounds intermittently. If the sensor detects an obstruction in the zone from zero to one metre behind the vehicle, a red light comes on steadily and the audible alarm sounds continuously.

The company sees a market both for new private and commercial vehicles and for fitting to vehicles already on the road.
What appears to be a rather simpler after-market system, the "Mini" series, is marketed in the United States primarily as a parking aid. However, it probably picks up children because, as the company=s literature states, *"Every 1.6 minutes, a driver is the US backs into trouble. Most accidents occur because the driver cannot see behind the vehicle. Children, toys, bicycles and other obstacles dent and scratch bumpers."* (It is interesting that the focus is on protecting the cars, rather than protecting the children!)

The "Mini 1 car reversing aid" is an automatic alert system that warns drivers of potential obstacles while backing up their vehicle. Acoustic sensors transmit a modulated beam signal. When the signal strikes a solid object directly, it bounces back to the receiver and transmits a signal to the microprocessor, which calculates the distance of the vehicle to the obstacle. The device is only activated when the driver puts the vehicle into reverse. The system alerts the driver with a variable multi tone audio pulse. The audio pulse intensity increases and the audio tone changes as the vehicle comes closer to the obstacle. There is also a voice distance module which speaks in a female voice at 8 feet, 5 feet, 3 feet and *"crash"* or *"hit"* within 30 cm. It will also say *"object in blind area"*. It may be bought as a package, at about $100 US. Other variants include a digital readout of distance, with a display mounted on the rear-view mirror.

Yet another American Product is the "ReverseGuard", released by a manufacturer of automotive safety products (American Road Products) in November 1999. The product resembles a standard registration plate frame and is intended to replace the rear frame on most private and commercial vehicles. Built into the frame are four ultrasonic sensors that alert the driver of objects behind his vehicle when it is in reverse. According to the company president: *"We realized the need for this product when a friend of ours, who was watching his granddaughter ride her tricycle in front of his home, nearly got hit by a neighbour's car that was backing out of a driveway. We also realized that all vehicles have a blind-spot, particularly the popular vans and sport utility [four-wheel drive] vehicles. That means any object within this blind-spot is at risk of being hit by the vehicle backing up. From our beta tests, we have found evidence that this product will significantly reduce the number of reverse-motion accidents".*

ReverseGuard automatically activates when a driver puts a vehicle in reverse, and detects objects in the path of the vehicle up to two to three metres. These sensors alert the driver to the object by emitting an intermittent alarm inside the vehicle. As the vehicle moves closer to the object, the alarm alerting the driver sounds more quickly until a steady alarm is heard, indicating that the vehicle is less than one metre from the object.

6 GENERAL DISCUSSION

The report of the Child Death Review Team has highlighted an important subset of the childhood injury issue: young children are being injured, sometimes fatally, by mostly large private vehicles and small commercial vehicles being reversed over them, commonly by parents, relations and neighbours. The numbers are small and are not consistently reported, because the injured children are not regarded under current definitions as road accident casualties. Only those who are fatally injured are documented by coroners' reports.

Identification of traffic-related injury, and in particular childhood injury, *not* occurring on public roads is falling through gaps in data systems in Australia. Although total numbers may be small, they are a substantial proportion of all children injured by motor vehicles, and especially the smallest children. The available figures from Australia, New Zealand and the United States suggest that it is the under-five-year-olds who are overwhelmingly the most likely to be injured in this way. The systematic work of institutions such as The New Children's Hospital in collecting injury data should be strongly encouraged.
It is regrettable that access was not able to be obtained for access to the original files of the Child Death Review Team, on which their discussion and recommendations were based. Without the detail that only the original files could reveal, it was impossible for the purpose of this project to compare the incidence of the these deaths in the CDRT and New Children's Hospital databases, compare the importance of locations such as rural and urban, review specific vehicle types beyond the broad categories defined, and more

precisely define typical patterns of environment and vehicle movement that had been factors in the fatal injuries documented.

Most of this information will be available for deaths that have been the subject of coronial review. This is so both for New South Wales and the remainder of the country. It would be desirable to undertake a national review of coronial files, perhaps after the National Coronial Database finally comes on stream. The numbers in such a review would probably be large enough to come to firmer conclusions and recommendations than have been possible in the present project.

Mainly because of lack of private or official recognition of the problem, there have to date been no systematic attempts to reduce the incidence of these events in Australia. Silence on the matter may be contrasted with the heavy private and official concern that addresses the issue of school bus safety, with even one injury being the subject of publicity, investigation, and countermeasure attention.

Thus, there is ample justification for the implementation of measures aimed at addressing the issue of driveway injuries to very young children, who are the obvious prime target.

Just as for child pedestrian injuries in general, the best approach is through the implementation of several complementary measures, rather than concentration of resources on single, high-profile activities such as mass media campaigns. The available research indicates that many of the children involved in these events come from families at some social disadvantage, who may be hard to reach and influence through activities conventionally addressing road safety.

In general, it seems that educational approaches will be most cost-effective if they are incorporated in the current activities of stakeholders already concerned with child safety, including the Institute of Early Childhood and its Early Childhood Road Safety Education Program, organisations such as Kidsafe NSW, road safety leaders such as the Roads and Traffic Authority, and hospitals such as the New Children' s Hospital. All of the above are well placed to highlight - both on a short-term and long-term basis - the importance of driveway safety.

Most of the research on child pedestrian deaths and injuries, on both public roads and private land, has come to the conclusion that environmental factors have been very influential. These factors become relatively more important the younger the child and the less open the child to the imposition of behavioural change. However, environmental safety is harder in some ways to address, although research has shown that environmental modification is the most likely to be successful. Fencing of driveways promises to be a highly effective measures, but again, may well not be appropriate for the kinds of household most at risk. The extent to which environmental modification is a practical

measure in New South Wales is a subject that could be addressed by a specific research project, through following up and obtaining more data on as large a sample of these injuries as possible.

Another most promising measure is encouraging the use of vehicle devices. A few new vehicles - all luxury models - are fitted with proximity sensors, intended as parking aids but with the potential for detecting the presence of nearby children. Although there is a rapid development of ITS systems for passenger cars, it will be a very long time before many vehicles with ITS detection systems are in general use, let alone with devices with a proven capacity to detect the presence of children, and let alone at a price that is affordable by the households most at risk.

However, there is an emerging market for detection systems that are aimed directly at concerned families, and intended precisely to detect the presence of unseen children and warn the driver. Such devices are coming on to the market in North America. It would be helpful to obtain samples of these devices, and test them under typical conditions in New South Wales.

Simpler and cheaper devices are lenses and mirrors which open up the field of view of a driver looking to the rear. The prices of such lenses are low enough to make them a practical proposition for safety promotional campaigns, and the manufacturer of the best known of these lenses might be open to an approach in this regard.

In summary, the tragic nature of these deaths and injuries make them a justifiable target for countermeasures of a widely disparate nature, spanning a wide variety of private and public institutions.

7 RESPONSES TO THE RECOMMENDATIONS OF THE CHILD DEATH REVIEW TEAM REPORT

1. The Motor Accidents Authority will liaise with, and encourage, all stakeholders in the issue of childhood injuries in driveways to incorporate information and educational materials on the issue in their present activities. The main objective will be the prevention of collisions involving large vehicles reversing into under five-year-old children. All educational activities should be well tested and evaluated, both before and after their formal implementation.

   Specifically, the organisations best placed to incorporate such material into their present activities are the Motor Accidents Authority itself, the Roads and Traffic Authority, The Institute of Early Childhood at Macquarie University through its Early Childhood Road Safety Education Program, the NRMA and the New Children's Hospital at Westmead.

2. The Motor Accidents Authority will encourage by all possible means, including liaison with all relevant stakeholders, the use of lenses and mirrors that facilitate a view of the area immediately behind motor vehicles, and especially large vehicles such as four-wheel drives and commercial vehicles.

3. The Motor Accidents Authority will seek to obtain samples of electronic sensing devices, now on sale in the United States for the specific purpose of detecting the presence of children near the rear of reversing vehicles, for testing under Australian conditions. If such testing produces favourable results, the Motor Accidents Authority will actively encourage their availability and sale on the Australian market.

4. The Motor Accidents Authority will approach the Local Government Association of New South Wales with the conclusions and recommendations of the present report, seeking comment and suggestions by the Association on how measures such as fencing of driveways should be encouraged.

5. The Motor Accidents Authority will correspond with the Australian Building Codes Board with a view to initiating the process of including in standards within the Building Codes of Australia guidelines for the physical protection of driveways where small children may be at risk.

6. The Motor Accidents Authority will propose to the Australian Transport Safety Bureau that it undertake a survey of national coronial records, in order to obtain nationwide figures on the incidence and basic factors underlying fatal injuries to children in driveways.

7. The Motor Accidents Authority will seek expressions of interest for the undertaking of a research project in New South Wales aimed at following up a sample of driveway injuries, with a view to obtaining more in-depth information on this sample.

8. Covering all the above approaches will be the implementation of an Action Plan developed in conjunction will all partners, with lead agencies, support agencies and potential costs all clearly identified.

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APPENDIX 1

IMPLEMENTATION PLAN

The purpose of this Appendix is to develop and recommend specific activities for the various government and non-government agencies that might be involved in the problem of childhood driveway injuries. In these specifics, it therefore goes rather beyond the general recommendations in the main body of the report, which is fundamentally a response to the recommendations of the Child Death Review Team.

Recommendations for action are divided into the following categories.

DATA COLLECTION AND ANALYSIS

The ***Roads and Traffic Authority*** should liaise with the ***Police Traffic Services Branch***, and seek to ensure that reports of fatal traffic-related accidents on private land are filed separately and systematically in a manner that would allow subsequent examination and analysis.

The ***Motor Accidents Authority*** should correspond with ***NSW Health*** to establish the status of any attempts to amend ICD coding in such a way that would permit the easy identification of driveway injuries.

COUNTERMEASURES: BEHAVIOURAL

The ***Roads and Traffic Authority*** should take every opportunity, when editing, issuing and amending road safety promotional material - especially that which relates to child behaviour and parental supervision - to note that traffic-related injuries in childhood can occur on private land and other off-road situations, and that the affected children are usually aged under five years.

The ***Roads and Traffic Authority*** should allocate specific funds to the ***Institute of Early Childhood at Macquarie University*** for the preparation of educational material centred on the risk of driveway injuries to small children, to be promoted and circulated through the Institute=s normal channels including workshops for early childhood educators.

The ***Roads and Traffic Authority*** and the ***Institute of Early Childhood at Macquarie University*** should use their existing lines of communication with Local Government Road Safety Officers to promote the issue at local level.

Kidsafe New South Wales should use educational material prepared and developed by the Roads and Traffic Authority and the Institute of Early Childhood, together with their own input, as part of Kidsafe activities. These could include material specific to Kidsafe House, and integrated with the programs and activities of the Kidsafe Playground Advisory Unit (especially in regard to the separation of play areas from traffic movement of any kind, including movement on private land).

The ***NRMA Insurance Group Limited*** should, as an extension to its normal road safety promotional efforts, prepare and circulate educational material aimed at parents, pointing to the dangers of the driveway and other traffic-related private environments to very small children. The material should urge not only extreme care and supervision but also the purchase of wide-angle lenses where the household uses large vehicles and has small children.

COUNTERMEASURES: ENVIRONMENTAL

The ***Motor Accidents Authority*** should approach the Local Government Association of New South Wales with the conclusions and recommendations of the present report, seeking comment and suggestions by the Association on how measures such as fencing of driveways should be encouraged.

The ***Motor Accidents Authority*** should also refer the issue of the design and fencing of driveways to the Road Safety Panel of the ***Institute of Public Works Engineering Australia*** (NSW Division), and, in association with ***NSW Health***, to the NSW ***Injury Prevention Forum***.

The ***Motor Accidents Authority*** should correspond with the ***Australian Building Codes Board*** with a view to initiating the process of including in performance-related standards within the Building Codes of Australia guidelines for the physical protection of driveways where small children may be at risk.

COUNTERMEASURES: VEHICLES

The distributors of suitable wide-angle rear window lenses (including Lion (Australia) Consolidated Pty Ltd) should be approached by the ***Motor Accidents Authority***, noting the present report and seeking suggestions for promotional efforts directed

at the safety of very small children in driveways in conjunction with other stakeholders named in these recommendations.

The ***Motor Accidents Authority*** should obtain from the United States one each of an example of the "Guardian Backup System" from Sense Technologies in Canada, a "Mini 1 Reversing Aid" from Autotoys in the United States, and a "Reverseguard" from American Road Products in the United States. These should be fitted to three typical vehicles for preliminary evaluation, with a view to a later more formal evaluation and perhaps encouragement for the import and more general use of the most effective of them. Obtaining, importing and fitting an example of each of the three should be at a cost of not more than about $1,000 Australian. A report could be contracted at a cost of about $2,000.

FURTHER RESEARCH

9. The ***Motor Accidents Authority*** should approach the ***Australian Transport Safety Bureau*** with the suggestion that the ATSB sponsor or undertake a study of all child fatalities in Australia in coroners' files, with the intention of systematically identifying and where possible examining the circumstances associated with those traffic-related fatalities occurring on private land.

10. The ***Motor Accidents Authority*** should seek expressions of interest from appropriately-qualified research teams, including the ***Injury Risk Management Research Centre at the University of New South Wales***, to undertake a five-year retrospective study of coronial records for deaths of children aged five years and under in New South Wales, identify all traffic-related deaths, and analyse the latter.

11. The ***Motor Accidents Authority*** should seek a research proposal from the ***New Children's Hospital*** at Westmead for the granting of funds to conduct a systematic, prospective follow-up of all injuries that come to the notice of the hospital - through Emergency Department or admission records - sustained to children aged five years or under. The follow-up should include visiting the premises and interviewing the people concerned, where possible. This project should desirably be included as part of the work of an existing research officer, with each individual follow-up and report being costed at about $500.

12. The ***Motor Accidents Authority*** should correspond with the Research Centre for Injury Studies at the Flinders University of South Australia, seeking further analysis - with the aid of a financial grant if necessary - of those data already collected as part of the Centre's 1997 review of child injury prevention and which relate to traffic-related injuries to children under five years.