Accidental child driveway runovers: exploring Waikato data and the efficacy of existing responses

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Chapter 1: Introduction

In the month preceding the beginning of this study, November 2009, a child was fatally injured in a driveway runover in the Waikato. In the same week, a second child was seriously injured in a Waihi runover accident. Several days before Christmas, a family in Auckland was struck with a similar tragedy, when a toddler died and his mother was seriously injured in a driveway runover. During the period of the study, another child was injured and hospitalised in the Napier-Hastings area and a further child was injured in a driveway in Manukau. Such traumatic accidents routinely feature in the news media and the Waikato case reached the front page of the *Waikato Times*. The cases also prompted a special report by TV One's *Close up* programme, which examined vehicle reversing visibility and a strategy for educating the public. While the numbers of accidents are not high, there is little doubt that driveway runovers are an ongoing, often fatal and inevitably avoidable tragedy for children and their families. In many cases the driver is an immediate family member, or a neighbour or friend, which serves to compound the tragedy. This type of accident is, like other unintentional child injuries, preventable.

A driveway runover injury for the purposes of this study is the unintentional injuring of a child (up to the age of 15 years) through the use of a motor vehicle of any type including but not limited to motorcycles, lawnmowers, trailers, and commercial vehicles, where the vehicle backs over a child while reversing down the driveway at a slow speed. Occasionally, the child is runover while the car is going forward. The injury must have occurred on a driveway but is not limited to the portion of driveway that is on a private property. That is, footpaths adjacent to driveways are also included.

New Zealand driveways present several hazards. They are usually relatively long with a garage at the rear of a section, creating several danger zones where visibility is impeded. There are also significant numbers of shared driveways servicing multiple homes. Fencing of driveways is not a mandatory requirement in New Zealand and many New Zealand children treat them as a place to play. Another factor implicated in this type of accident is the increasing prevalence of larger 'people mover' and four wheel drive type vehicles. As vehicles increase in size, the reversing visibility decreases, resulting in blind spots of more than 27 square metres for some of these vehicles (State Insurance, 2005). A third factor commonly identified in driveway runovers is the human factor, encompassing knowledge or awareness, driving behaviours, parenting practices and socio-economic elements.

Because the victim is a small child, driveway runover survivors tend to suffer major trauma and often serious long term effects from the accidents (Cowley et al, 2005; Chambers, 2007). Hsiao et al (2009) found that there were 9 driveway fatalities involving children under 15 years of age in the Auckland region between November 2001 to December 2005. Chambers (2007, p.3) notes that there are on average 4 fatalities per year involving runovers on private driveways with an average of 2 children being hospitalised every week; over the last 10 years rates of runover incidence have remained steady. According to Chambers (2007) the lack of public/community awareness is a major cause of accidents. Improving public awareness is therefore a primary consideration of this research.

The over-riding objective of this study is to find ways to minimise the incidence and severity of driveway runovers. We also aim to add Waikato data to the existing knowledge base and therefore we have collected data on driveway injuries and

fatalities occurring in the Waikato region and analysed these in terms of how they either support or differ from the evidence in existing research. We have reviewed the literature with regard to previous recommendations for reducing the incidence of driveway runovers and reconsidered the efficacy of existing strategies. We have also investigated the availability and accessibility of relevant educational resources for drivers and families in Waikato, noting how any gaps or limitations in disseminating such information might be addressed.

This report begins with a description of the research process utilised in this project, which combines a literature review with the collection of Waikato data and a review of available resources. Chapter Two presents the literature review, dividing the material into its different sources, then summarising the literature in terms of the three main factors contributing to driveway runovers. The following chapter provides data on Waikato driveway accidents for the period since May 2006. The type and availability of educational resources is then presented. Chapter Four evaluates existing resources and their availability, suggesting how they might be made more accessible to families. It also assesses existing recommendations and provides further suggestions for enhancing driveway safety. These again reflect the three main categories outlined in the literature – human, vehicle and environmental.

Methodology

A study undertaken for CAPFNZ[4] by Waikato University students in 2005 incorporated a comprehensive review of the existing literature at the time. This project picks up the review to cover the years since 2005, but also utilises the older resources. Several databases were searched, including Proquest 3000 through the Waikato University Library Online Database, the internet, the Safekids NZ Information and Resource Centre, websites belonging to the Waikato District Health Board (DHB), Auckland DHB, Counties-Manukau DHB, Waitemata DHB, New Zealand Land Transport Safety Authority and Statistics New Zealand.

With the assistance of Safekids, keywords used in previous research were isolated and used in this project. The keywords (and subsequent combinations) used in the searches fell into several different categories, such as vehicle type, location, accident type and victim. Thus location included terms such as driveway(s), footpath(s) and off road, while accident type encompassed runover(s), rollover(s), roll over(s), and drive over(s). Similarly victims were searched using terms such as baby, children, toddler(s), boy or girl and vehicle types ranged from car(s) to van(s), truck(s) and SUV(s). The data that were gained through the searches tended to be very specific to the topic and easily differentiated from non-includable data.

We divided the literature into three different categories: academic, medical and generalist. There have been few academic studies published since 2005, but there is a large body of information regarding child safety and driveway safety available through the Safekids repository and some relatively recent medical literature.

In past medical studies of paediatric driveway injuries, trauma registry data has been the primary source of data. By using a single source, any risk of double counting can be minimised. Data falling outside of the search parameters used however, would obviously not appear in the results. For this reason additional data was gleaned from media reports. The Waikato Trauma Registry data covered a period from May 2006

[4] The Child Injury Prevention Foundation of New Zealand was formerly known as the Child Accident Prevention Foundation of New Zealand.

up to April 2009. Therefore media reports were used to augment the data from the registry for the period from the end of April 2009, without risk of double counting.

A key limitation of accessing information through a trauma registry is the restriction presented by the particular keywords used. The process is necessarily exclusive of any cases where alternative terms and phrases have been used to record the accident. In essence, this reflects the human element in data recording since in every admission form there is a free text space for recording injury data. The words used in this free text area are at the discretion of whomever is in attendance and how they interpret the injury. For example, an incident may have taken place on the road outside of a driveway but directly adjacent to the driveway by a reversing vehicle, but is coded as a road accident. Such an accident would be of direct interest as it would fall within the scope of this research, but would be unlikely to appear in any searches and therefore would remain uncounted.

Collection of Waikato Data

Past research has found that the most reliable data source for accidents has been the use of the trauma registry's dataset regarding admissions to District Health Boards. Waikato DHB is made up of a large catchment area where 5 hospitals service the region. The Midland Regional Trauma System is relatively new – indeed it was officially launched while this research was in process. Five hospitals contribute to the database. They are Bay of Plenty Trauma Service, Lakes Trauma Service, Taranaki Trauma Service, Waikato Trauma Service and Tairawhiti Trauma Service. It has a sister system in the Auckland region, for which data come from Auckland Hospital, Starship Hospital, and Middlemore Hospital (May, 2007). Past research by Cowley et al (2005) and Chambers (2007) has highlighted the need for centralised data collection to improve the accuracy of information gathered. Centralised collection largely removes problems of variances in coding and the new registry promises much more consistency in the future. Data were clearly defined and accessible in our research project, though the human element continues to confound the data at times. For example, one area of concern was the category, "location of accident". This category elicited responses such as "home" or "driveway", which were self-explanatory, but other entries recorded "recreational" in this category, which was less helpful.

Waikato Director of Trauma, Mr. Grant Christey, enabled us to access driveway runover data by searching the trauma registry data base using a key word text search of an unbroken dataset covering the period from May 2006 to August 2009. The same sets of keywords used in the literature search were applied to the registry data.

Educational Resources

Early reading on the topic indicated that awareness of the risks that driveways pose to children is not widespread. We therefore sought to establish what sorts of educational materials existed and how readily available they might be to Waikato parents. While we found that information does exist (for example, Safekids has posters, safety kits, DVDs, position papers and links to further resources available on its website), access to it is problematic. It is reasonable to assume that most parents would not be aware of the resources available from Safekids and would be more likely to seek information locally, if at all. We therefore attempted to find some/any of the Safekids resources at local organisations frequented by parents. These included medical centres, hospitals, childcare centres and Plunket in Hamilton and

Cambridge, as well as Environment Waikato. An inquiry was made to each organisation as to whether they had any information relating to driveway runovers at hand, and what it was. If not, they were asked if they could provide information on where to find educational resources such as pamphlets, posters or educational kits.

Drawing these strands together, we discuss the Waikato data in relation to previous research and review existing recommendations and strategies. Finally we offer some recent innovations as possible solutions for properties developed prior to current regulations governing vehicle access to residential properties. We also suggest methods of ensuring regular dissemination of relevant educational material to families.

Chapter 2: Literature Review

Academic sources

Since the Waikato study in 2005, there have been few major academic studies into driveway runovers both nationally and internationally. Publications at the national level have been primarily concerned with the occurrence of driveway accidents in Auckland, such as paediatric studies conducted in Auckland using Auckland data. We could find no international studies in the period since 2005, although there were a number of studies conducted in Australia and the United States in the 1990's. The study of driveway accidents in New Zealand dates back to 1992 when the first study, *Non-traffic child pedestrian injuries*, was published by Roberts et al. As noted above, the literature falls into three broad categories and we treat them individually below.

Medical sources

Medical research (largely focused on the Auckland region) has highlighted the high rate of serious to fatal consequences of paediatric driveway runover accidents, which is related to the small size of the victim, rather than excessive speed of the vehicle (Beasley, 2009; Hsiao et al, 2009). An investigation of driveway accidents by Hsiao et al (2009) involved children under 15 years of age who either died or were admitted to hospital as a result of being runover by a vehicle on a domestic driveway in the Auckland region. The fifty month project spanned November 2001 through to December 2005 and data collection encompassed factors such as accident and environmental characteristics, demographics and parental awareness. The report recognised 93 cases, including 9 fatalities and the average age of the victims was 2 years.

The literature also shows that close family members – often parents – are likely to be the drivers of the vehicles involved in driveway runovers. Accidents are more likely to occur in the summer months and in the late afternoon (4-7p.m.), rather than in the morning (Beasley, 2009). Summer afternoons, of course, are times when families are more likely to be active outdoors. Daylight saving and warm weather result in accidents peaking in December (Beasley, 2009). Technical and environmental factors also contribute to driveway runovers. For example, variations in vehicles' visibility index are a key factor, especially when drivers are not aware of the extent of the blind spot of their particular model of vehicle. This exacerbates a more general lack of awareness of the risk involved in not knowing exactly where children are while reversing down driveways (Beasley, 2009). The lack of fencing within properties has also been noted as a key contributor to runovers, since on many New Zealand sections there is no practical distinction between play areas and driveways.

Generalist sources

Generalist sources include publications from government departments and other organisations with an interest in safety, such as Safekids. Some of the literature is in the form of reports and articles, though much is also available as fact sheets, electronic resources, posters and pamphlets. Cowley et al (2005) note that New Zealand has one of the higher rates of driveway runover occurrences in the urbanized world, with children from lower-socio-economic groups being at more than five times the risk of driveway runovers. They also found that record keeping and data collection presented major problems for driveway runover researchers. This was largely attributed to inconsistencies in categorising and coding data. For

example, runovers were sometimes classified as pedestrian injuries which resulted in an understatement of the extent of the problem. Two years later, Chambers (2007) reiterated the need for data collection systems to be improved, also noting there is no national database for collating statistics of such accidents – indeed there is no national database for child accidents of any type.

Chambers (2007) reiterates the three common factors found in earlier research – human, vehicular and environmental – and points out that many residential dwelling entrances open directly onto the driveway, especially established homes. Vehicle design and poor reversing visibility are also noted as key factors in the accidents. According to Chambers further research is required to inform experts and policy makers of the factors involved and optimal methods of reducing the risks. Chambers also includes discussion of the injuries sustained by young victims of driveway runovers. Their injuries and usually serious and often fatal due to their size, with most harm occurring to the upper body, i.e. head and neck/chest regions. Past studies (e.g. Cowley et al, 2005) have noted the high incidence of runovers in South Auckland and made links with the socio-economic status of the area, the prevailing types of housing and the higher rates of large families, each of which has a compounding effect. That is, the housing stock is largely of an era that incorporates long driveways, there are more children likely to be playing on the driveways, but fewer resources to effect change to the environment or upgrade to vehicles with better visibility.

The Chambers (2007) report made very specific recommendations, which included calling for territorial authorities to have improved regard for the risk of child driveway accidents. The report made further recommendations applying to the transport industry and the need to improve rearward vehicle visibility. Chambers also quoted a UNICEF report in which New Zealand ranked last of all OECD countries in 2007 in terms of child health and safety in general. In a 2009 report comparing OECD countries, New Zealand had improved only one slot, ranking twenty-ninth out of 30 countries, just ahead of Turkey (OECD, 2009).

A publication released by the Land Transport Safety Authority (now part of the NZ Transport Agency) promised much in its title, *Guidelines for visibility at driveways*. Unfortunately, the publication has nothing to do with driveway visibility in relation to pedestrians on the driveway. Rather, it addresses the issue of the necessity for clear lines of sight between footpath pedestrians and exiting vehicles and since it is a guideline, there are no legal requirements for its observation.

In 1996, the Safer House Design Committee published a new NZS standard covering vehicle access on residential properties. Several contributors collaborated in the preparation of the standard, with input coming from agencies and organisations such as Plunket, the New Zealand Fire Service, the Ministry of Commerce and the Ministry of Consumer Affairs, the Foundation for the Blind and ACC. The standard contains detailed design considerations for vehicle access onto residential properties. It includes lighting considerations, visibility on and adjacent to the driveway, and the need for clear identification of garaging and parking on sites. Of particular note in the standard is the requirement to fence off parking and garaging from children's play areas in all new dwellings; it also stipulates that garaging should be as close to the entry of a dwelling as possible. Housing design however, has changed considerably since 1996, with many more areas now zoned for high density residential development. The standard therefore fails to address apartment complexes and has never taken into consideration housing design where a shared driveway is utilised.

Media sources

A plethora of material reporting on specific driveway accidents was found through a search conducted by Safekids NZ on behalf of the researchers. The scope of the reports ranges from 2006 (where none were found) to 2009. Prior to 2006 the reports become increasingly difficult to check.

Of the material received for review the articles corresponded well with the data from the trauma registry. In most cases the article states the types of injuries sustained, the relationship (if any) between the driver of the vehicle and the victim, who was caring for the child at the time of the accident, and in some reports, whether the Police or Child Youth and Family Services were involved. The type of vehicle involved was less commonly stated. Overall, the majority of those driving the vehicle were close family members, though in a few instances neighbours were driving. Media interviews with some of the families involved, while heartbreaking, were also instructive in as much as the lack of awareness was a constant theme. It was clear however, that "awareness" occurred at multiple levels. Most drivers were unaware of the actual size of the blind spot of their vehicle. Some drivers were not aware that children were in the driveway at all, while others were unaware that a child had moved into the driveway after they had checked for the whereabouts of any children on the property. In the time it takes to physically exit a vehicle, check behind and re-enter the vehicle a child can come from nowhere and place him/herself in the path of the vehicle whilst remaining invisible to the driver due to their physical size and the blind spots in vehicles.

Late in 2008, a number of newspapers published an article that was a summary of child driveway runover accidents in New Zealand, written by Ann Weaver, Director of Safekids NZ, following a further driveway fatality. In attempting to raise levels of awareness, the article informed readers that two children are killed each week in this country and the equivalent of a classroom of children are injured each day through various means. Published on 17th September, the article warned that as summer approached driveway accidents were likely to increase as children played outside en masse. In the summer of 2009-10, a spate of driveway accidents occurred, coinciding with the beginning of this study. Sadly, they continued to occur throughout the summer, including the week of the final edits of this report in late February 2010, when a toddler in Rotorua was injured (NZ Herald, 26 Feb, 2009).

Media reports that coincided with the release of the Hsiao et al (2009) study comprise a third type of media release. In addition to press reports, key personnel were interviewed in other media. For example, Professor of Paediatrics, Spencer Beasley discussed the report on Radio New Zealand. Professor Beasley noted that nothing had changed since the last study in 2002, that the accident rate is shameful, an education campaign is required and there is a need to take measures to fence properties. In November 2009 Television One aired a story on driveway accidents on their *Close up* programme. Host, Mark Sainsbury stated that New Zealand had the worst record in the world for driveway accidents. The programme featured an interview with a family whose father had run over his son. Thankfully, in this case the child survived.

The programme also included a demonstration of rearward visibility in cars which was filmed in Sydney, Australia. The demonstrator commented that it is not simply SUV and 4WD vehicles that perform badly, but amongst the worst are medium and

large (family-sized) cars. Ann Weaver Director of Safekids NZ was interviewed about driveway runovers and also about a visibility demonstration kit readily available to the public. She stressed that active supervision is required and that the accidents were not attributable to complacency but to a lack of awareness. Ann wanted to see the resources that Safekids holds and the educational kits and programmes that have been developed rolled out throughout New Zealand. Safekids did not advocate reversing sensors as any alarm noise generated was an attractant for children rather than a deterrent. The use of reversing cameras was recommended as the best option.

The literature presents numerous options for the prevention of driveway runovers and these tend to fall into three main categories – modifying behaviour, modifying the environment and modifying vehicles.

Modifying behaviour.

Behaviour modification is generally accepted as best effected through education. Accordingly, Cowley et al (2005) suggests that the dangers of driveway runover should be included in the *Road Code*, as well as being incorporated into driver's license testing. Beasley (2009) suggests improved publicity about the accidents to a wider public. Driver education is a particular area of concern, especially initiatives addressing driver awareness and inattentiveness, though education also needs to cover those with childcare responsibilities. Hsaio et al (2009) advocate behaviour changes combined with better community awareness about the dangers of accidents could be best supported by enhanced education programmes. They suggest including specific lessons on the topic as part of antenatal classes, so that future families can be introduced to preventative awareness strategies.

Modifying vehicles.

Beasley (2009) highlights vehicles' blind spots as a key issue and notes the need for visual aids, such as convex mirrors, and proximity detectors as preventive measures. In 2007, the Australian motoring organization NRMA, studied the blind spots of 270 vehicles. This study underpins the Reversing Visibility Index, available to New Zealanders through the State Insurance website (State Insurance, 2005). NMRA found that less than 1% of the vehicles reviewed scored well enough to receive a maximum rating for being able to see a two-year-old behind the vehicle (NZAA, 2010). Family style sedans scored poorly due to the trend for low front and high rear end design, combined with smaller rear windows. The most highly rated vehicles were 4WDs fitted with reversing cameras, which can be installed on most vehicles. They can be mounted higher up to compensate for high rear end design. Reversing sensors are now appearing on new cars and becoming more commonplace with a kit allowing easy installation on most vehicles (Auto trader, 2010; Consumer, 2010). These 'ultra-sonic' sensors have the ability to detect a toddler or child. The sensors are recess fitted to the bumper of a vehicle and can sense objects up to 30 metres away. There is an audible buzzer fitted under the dash with a volume control and an "off" setting. Most models increase the frequency of the sound as the object gets closer to the vehicle.

Modifying the environment.

The most common environmental factor associated with runover accidents is the failure to separate driveways from children's play areas (Hsaio et al, 2009; Chambers, 2007; Cowley et al, 2005). Housing design in the Auckland and Waikato

areas is similar. Houses are located at the front of sections and garaging is located at the rear, necessitating long driveways. In both regions, driveway fencing is rare. This is evident by surveying suburban areas, in both Auckland and the Waikato, on Google Maps. Beasley (2009) found long driveways to be high risk areas precisely because they are so inviting for children to use as a play area and there is usually no physical barrier separating the house entrance and the driveway. Chambers (2007) notes that access to the driveway is often obtainable from both the front and back of properties and cites the findings of Hsaio et al (2009) wherein a salient feature was the existence of driveways shared between dwellings and running the length of the property. Again, the driveway tended to be merged as part of the children's play area.

Chapter 3: Results

Waikato Data

The Waikato Trauma Registry provided information on driveway injuries to children under the age of 15 years for the period May 2006 to May 2009. We asked the Trauma Registry for information about the type and severity of injuries sustained, vehicle type, and the location and time of the accident. We also sought demographic data such as age, gender and ethnicity. The data covered eight hospital admissions and a further two cases were added to the data, having been sourced through media articles supplied by Safekids NZ in late 2009 and early 2010. They included one child who miraculously suffered no injuries despite being runover both backwards and forwards in his driveway (Feek, 2009). The second media article reported substantial injuries to a 1-year-old female runover forwards in her driveway in Waihi (Mcpherson, 2009).

Because fatal driveway runovers will not necessarily be processed through a hospital (and therefore will not be included in Trauma Registry data) we also sought information from the Coroner's Office. We submitted specific questions for the same period covered by the Trauma Registry data. The specificity of the questions was necessary to avoid double counting. Unfortunately, at the time the request was made the service was undergoing changes which would have delayed a response beyond the date of completion for this report. None-the-less, we are confident that we have not omitted any driveway runover fatalities during the period under study. This is due to the comprehensive coverage of relevant media articles provided by Safekids NZ. Two deaths were established through media article representation. They were a 17-month-old male on a neighbour's driveway in Matamata (Feek, 2008) and a 21-month-old female in her home driveway in Whatawhata, on the outskirts of Hamilton (Ihaka, 2009). In total then, the data covered ten injury accidents and two fatalities.

As noted above, the impact of a vehicle reversing over a small child often presents critical long term injuries. Accident patients are ascribed injury ratings on a numeric scale which indicates the severity of the injuries sustained to different parts of the body. Using the Abbreviated Injury Scale (AIS) an injury severity rating of 1 indicates minor injuries, such as abrasions and bruising of the arms, legs or chest (Copes et al., 1989). The highest possible injury rating is 6, which indicates unsurvivable injuries. The different AIS scores for each area of the body are then used to establish an Injury Severity Score (ISS), where the scores range from 0 (no injury) to 75 (unsurvivable injuries) (Baker et al., 1974). An AIS rating of 6 for any area of the body automatically translates to an ISS score of 75. The highest score recorded in the Trauma Registry data was 22.

Of the eight injury cases recorded by the Trauma Registry (see appendix 1), three were female and five were male. Seven of the victims were Maori children and the other was recorded as European. As has been noted in other research, driveway runovers most often involve pre-school-aged children and the ages of the victims in this research ranged from 1 year to 5 years. We also note that fewer accidents occurred in 2006 (1) than in 2007 (3) and 2008 (4), suggesting an increasing rate in the Waikato region, though the data are not sufficiently extensive to establish such a pattern. While most of the accidents are recorded as occurring in a residential driveway, three of the cases had confusing information in the category of "location". In each case, the word "recreation" was recorded as the place of the accident, but it

is unclear what this related to. Possibly the child was simply playing in the driveway; it is also possible that the accident occurred in a place of recreation, though the former explanation is the more likely.

As is predicted by previous research, the accidents recorded the in Waikato data occurred predominately in the afternoon times and over the warmer months, more active months of the year. Both fatalities occurred in the higher risk period of late afternoon. Injury severity scores (ISS) ranged from children having an ISS of 1 resulting in 2 admissions through to a highest score of 22. In this case (ISS = 22) the child was one year of age and suffered lacerations to the head and multiple fractures of bones, along with a number of other minor injuries. Another child (ISS – 9) was reversed over by a ride on mower and sustained some amputation in the region of the mid right foot. In both cases the child was unseen and moved into the danger zone quickly without the driver realising

The types of vehicles involved were predominantly cars, though a truck was involved in one accident and as noted above, one was a ride on lawn mower. One case that was included in the Trauma Registry data was excluded from our findings. There was the admission of a 14 year old boy who jumped across the driveway and tripped. No vehicle was involved in this injury, therefore the case did not fit the criteria for runovers.

Variations in data collection processes make comparisons between Auckland and Waikato difficult, but it is possible to make some broad observations. The Auckland region encompasses three separate DHBs: Auckland, Waitemata and Counties-Manukau. Together they cater for a population of about 1.4 million (Auckland DHB website). The Waikato DHB population is in excess of 350, 000 people (Waikato DHB, 2008), indicating that the population served by the Waikato DHB is approximately 25% of the corresponding Auckland population. Theoretically, we might expect the rates of driveway runovers to be consistent between the regions. That is, we would expect the number of accidents occurring in the Waikato to be about 25% of the Auckland occurrences. Between January 2006 and December 2008 there were 43 driveway runover accidents in the Auckland area, of which 4 were fatal (Jones, 2009). In the Waikato between May 2006 and April 2009[5] there were 9 incidents, including 2 fatalities (Waikato Trauma Registry). The statistics indicate a disparity in the rates of this type of injury between regions in that the occurrences in Waikato were about 20%, rather than 25% of the corresponding Auckland figures.

The lower rate of driveway accidents in Waikato merits some comment. One consideration is the largely urban population of the Auckland region in comparison to Waikato. Waikato has a population that is spread through the region, with 40% living in rural zones and a further 20% living in towns other than Hamilton city (Waikato DHB website). Previous research finds that driveway runovers occur most frequently in urban areas with older housing stock. The problems associated with long urban driveways appear not to be transported to the often longer driveways found in rural areas. We also note the differences in population density, which would predict that rates will be higher in urban areas and this effect is compounded by the higher than average family size that prevails in South Auckland, where driveway runovers occur most frequently (Chambers, 2007).

[5] Herein is an example of the problems of inconsistencies in data collection. Data for exactly corresponding time periods were simply not available.

Educational resources

As noted earlier, there was a clear lack of available resources on the prevention of accidental driveway injuries to children in the Waikato, despite the large collection that Safekids has developed. There was, however, one notable exception. The Plunket Society operates nationwide and is a major sponsor of Safekids NZ. The Plunket Society has access to educational resources from Safekids and disseminates them in both the Auckland and Waikato regions as well as the rest of the country. Driveway safety is not the primary concern of the society however, and while information is available, there is no specific campaign in place to increase awareness amongst families.

Informal discussion with Environment Waikato provided information on a local road safety initiative. Environment Waikato administers and operates the 'Ruben the Road Safety Bear' campaign. While the campaign does not specifically address the subject of child driveway injury prevention, it does advocate road safety in relation to child pedestrians. There are seven specific messages delivered by Ruben, two of which pertain closely to the topic: *Look out for sneaky driveways* and *Look about before stepping out.* The *sneaky driveway* message pertains to driveways that are visually obscured for the driver which can pose a threat to pedestrians on footpaths. The *look about* lesson is about ensuring there is no vehicular threat in busy places such as carparks, or where cars are moving about. The Ruben programme is free and is offered to schools, preschools and child care centres throughout the Waikato region. It has also been used in the Bay of Plenty region. In the year to June 2009, Ruben visited 13,745 children and from the 1st of July 2009 to date, Ruben was seen by approximately 9300 children (J. Davis, personal communication, December 14, 2009). The education provided by Reuben is aimed at children, allowing for a degree of incidental adult education, assuming the child shares the learning with their parents at home. There is no direct adult education and the Ruben campaign falls short of directly addressing driveway runovers.

Environment Waikato is familiar with the 'Spot the Tot' kit[6] and has investigated adding it to their current message. However, this type of kit requires adult interaction, and it currently lies outside the target group for the campaign. 'Spot the Tot' may be better suited to school fairs and galas where there is a high proportion of adults in attendance. Another factor to consider is funding for such programs. Environment Waikato relies on funding from rates revenue and last year in Waikato there was no rates increase (after inflation), which limits any plans for extending the scope of the campaign. Partial funding comes from the New Zealand Transport Association, though this is not guaranteed and withdrawal of these funds may truncate the service already provided.

Recent innovations

Stainless Steel panels

In 2005, Cowley et al recommended convex mirrors as a practical means of addressing blind spots in driveways, their cost is prohibitive and given that they are made of glass, breakage may be a problem. A more affordable and more robust

[6] This is a 0.6m X 6.7m plastic sheet marked with the 'Spot the Tot' message and logo at 0.6m intervals. The demonstration involves laying out the kit behind a vehicle and then placing a small child on the spaced intervals until it can be seen by the driver, thus reinforcing how large the vehicle 'blind spots' are, especially when a driver is backing.

option may be to instead use stainless steel reflective panels. These are highly polished pieces of stainless steel, which can be mounted on the garage, fence or house to optimize visibility for reversing vehicles. A run of 1000 units of a size of $0.5m^2$ could be produced for $50-$70 per unit, with this price reducing further for longer runs (Southern Hospitality 2010). This presents a more viable option for families and may be more palatable to policymakers to consider subsiding installation in high risk households. Installation however, does not guarantee drivers will make use of the device. (Southern Hospitality 2010; Cowley et al., 2005).

Fencing

While new dwellings are governed by regulations introduced in 1996, older homes remain problematic in regard to permanent fencing. Taking a flexible approach to the problem allows for consideration of two options which may offer viable and affordable alternatives to permanent fencing: the *Kidcatcher* and the *virtual fence*.

Kidcatcher

The Kidcatcher is a practical, easy to use driveway safety device in the form of a durable net that could be used to separate the driveway from the house entrance to keep children away from the driveway in times of high vehicle use, most notable during the late afternoon and early evening. It has been specifically designed to be a physical and visual barrier that prevents children from running out onto the street and it has huge potential as a means of separating the driveway from the house entrance/play area. As a visual barrier, it serves to warn drivers that it may be unsafe to enter the driveway and also gives peace of mind to the reversing driver in regard to the whereabouts of any children on the property because it prevents them accessing the driveway (Kids Safety Klub, 2010).

The current model of the Kidcatcher is 25 feet in length and is adjustable to fit driveways one to two cars wide. It is a durable reinforced (tensar) netting material that can withstand being run over by vehicles and is available from the United States for US$107 (Kids Safety Klub, 2010). This preventative net could be enhanced to be an effective safety aid in the prevention of driveway runovers and since it is portable, its use is not restricted to just one property, but could be taken by families moving house.

The virtual fence

A further alternative to permanent fencing is a device which acts as a virtual fence. It is a system which has been available for many years and has primarily been utilised in industrial safety applications. It consists of two sensors that are linked by a light beam that can cover distances up to 30 metres. It is easily installed and could act as either a deterrent to children or a warning for drivers (or both), when used in conjunction with a warning siren and/or light. The sensor forms a circuit that when broken by an object, in this case a child, activates any warning device attached to it. The sensors and ancillary components are readily available offer a cost effective practical alternative to fences. The sensors retail at around $300. The total price including sirens or warning lamps and wiring installation would be around $700, which is substantially less costly than permanent fencing. Like the Kidcatcher, it is also portable and can move with the family. Its main disadvantage is that visiting drivers may not be aware of what the warning device means if triggered. The effectiveness of the device would therefore need to be augmented with a public education campaign.

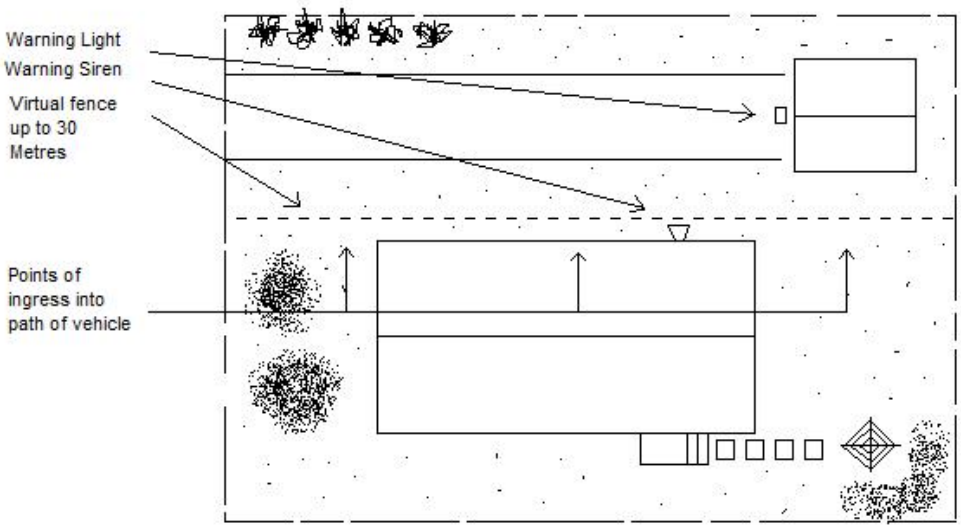

Fig 1. Suggested placement of a virtual fence on a typical New Zealand residential section.

Chapter 4: Evaluation and recommendations

Previous Recommendations

The literature presents numerous options for preventing or minimising the risk of driveway runovers. Most of these were drawn together in a comprehensive set of recommendations by Cowley et al in 2005 and have been reiterated in later studies. They fall into three main categories – modifying behaviour, modifying the environment and modifying vehicles.

Modifying behaviour.

Behaviour modification is generally accepted as best effected through education. Accordingly, Cowley et al (2005) suggests that the dangers of driveway runover should be included in the *Road Code*, as well as being incorporated into driver's licence testing. Hsaio et al., (2009) argue that behaviour changes combined with better community awareness about the dangers of accidents could be best supported by enhanced education programmes. They suggest including specific lessons on the topic as part of antenatal classes, so that future families can be introduced to preventative awareness strategies. The importance of the child's caregiver/minder being vigilant of the child at all times when playing on driveways and around vehicles is a crucial message that researchers recommend consistently and repeatedly (Cowley et al, 2005; Chambers, 2007; Hsaio et al, 2009; Beasley 2009)

Beasley (2009) suggests improved educational publicity campaigns about the accidents to a wider public. The opportunity for achieving this informally has sometimes been provided following media reports of accidents, in as much as media interviews have allowed Safekids Director, Ann Weaver to emphasise the risks and increase public awareness of the scope of the factors which contribute to driveway runover accidents (Safekids, 2009). The same process can also provide insight and commentary from the people most closely affected by a driveway runover - the family of the victim, who must cope not only with their loss, but also with their role in the accident as caregivers and/or drivers. Their comments invariably revolve around the need for constant vigilance and the speed at which situations change. Repeatedly, awareness (or lack of it) emerges as a key factor in the accidents. Prevention of the accidents through increasing levels of awareness is of utmost importance in delivering safety messages to families and the community, according to Chambers (2007). She advocates the "recruitment of champions who are committed to reducing driveway injury" to assist in driving any public educational initiative, since having high profile people involved in prevention campaigns automatically raises the level of public awareness (Chambers, 2007, p. 14).

Modifying vehicles.

Beasley (2009) highlights vehicles' blind spots as a key issue and notes the need for visual aids, such as convex mirrors, cameras and proximity detectors as preventive measures. The most highly rated vehicles in Australia's NMRA study (2007) were 4WDs fitted with reversing cameras, which can be installed on most vehicles. They can be mounted higher up to compensate for the high rear end design of many contemporary vehicles. As noted above, reversing sensors are now appearing on new cars and becoming more commonplace on older cars. Alarms that beep while reversing a vehicle may warn the driver of impending problems, but they can also

have a perverse outcome for toddlers. As others have noted, small children do not comprehend the dangers of a moving vehicle and can be attracted to the noise, effectively increasing the risks, rather than overcoming them.

Chambers (2007) suggests that the installation of rearward cameras and sensors can reduce the likelihood of accidents, though the cost of high-tech solutions such as these can be prohibitive. She points out that the Reversing Visibility Index, introduced to New Zealand by State Insurance provides ready information for car owners and buyers, though public awareness of the index appears to be low. Detailed testing of other aids showed that sensor based parking aids were very limited in range, giving a more random result which in turn limited the efficacy of the device in preventing runovers (Chambers, 2007). Chambers describes reversing camera systems as having the most positive impact in reducing runovers, but notes that the performance of the technology is affected by bad weather, such as rain, fog etc. Most importantly the driver's interaction with the camera device screen has much to do with its efficiency. Driver distraction and being lax about driver safety awareness along with speed were barriers to the helpful use of this product (Chambers, 2007). The price of cameras has reduced over the years from $1000 (Cowley et al, 2005) to products that are available from $250-$350 uninstalled, or around $550 for a fully installed device. Although now much reduced in price, the cameras would still be beyond the means of many families.

Modifying the environment.

The fencing of driveways as a preventative measure features prominently in the literature. Separation of children's play areas and driveways is one way to combat accidents through preventative safe guarding of the environment. According to Beasley (2009) long driveways are high risk areas as they are often used as a play area for children and often there is no physical barrier separating the house entrance from the driveway. Newer houses, by contrast, tend to be built with the garage in the front of house, minimising the length of the driveway. Section sizes are also smaller, further reducing the likelihood of long driveways. None-the-less, there is a continuing need for closer collaboration of accident prevention researchers with the building industry and legislators.

Homes in New Zealand are diverse in their design and construction, which poses problems for the fencing of existing homes in terms of cost, and efficacy (Chambers, 2007). Some properties simply do not lend themselves to this type of fencing because access to the house itself would be blocked. Beasley points out that, even in cases where fencing driveways off as a preventative safety measure is a practical option, affordability is a major drawback, especially for lower socioeconomic groups. The same group is also unlikely to own vehicles with proximity sensors/rear cameras to improve visibility of the driveway while reversing. In an effort to overcome the problems with high costs, Cowley et al., (2005) suggest safety fencing could have some form of government subsidy via local authorities. Hsaio, et al., (2009) notes that more research is required to find a way to implement this kind of separation of driveway and play area affordably. Fencing of properties is therefore something of a conundrum: it is the most effective and most frequently recommended means of protecting children from driveway runovers, but it is also costly, not a legal requirement and sometimes impractical.

Modifying the environment is not confined to fencing arrangements, however. Beasley (2009) emphasises the driveway blind spot – as opposed to the vehicle blind spot – as a problem. Most commonly this occurs when vehicles undertake a 3-point

turn within the property so as to exit forwards. Previous researchers have suggested convex mirrors as a means of eliminating the blind spot by being attached to the house/garage as a visual aid when turning or backing down driveways (Cowley et al, 2005). The mirrors are not readily available to the public, however and in Hamilton they need to be ordered by the consumer through glass merchants or safety shops. In retail outlets, there are no in-store displays of the product and there is no promotional material advocating their use in residential driveways. Consumers are limited to perusing pamphlets for information on the mirrors. At a cost of $200-300 each, glass mirrors are not unlikely to enjoy widespread use in domestic situations (Bennett Mirror Technologies Limited, 2009; Cowley et al., 2005)

Evaluation of Educational Resources

The efficacy of educational campaigns undertaken by Safekids in the Auckland region is clearly demonstrated in the declining rates of child driveway injuries since 1992. On average in Auckland between January 1992 and February 1994 there were 2.11 injuries per month. This fell to 1.86 injuries per month between November 2001 and December 2005, with a further fall to 1.19 injuries per month in the two years to December 2008 (Roberts, et al., 1992; Murphy et al., 2002; Hsaio et al., 2009). Over the period since 1992 there have been no initiatives to enforce or subsidise fencing of driveways, nor has there been any legal requirement for reversing cameras. There has however, been a consistent educational strategy undertaken by Safekids, suggesting that the improved statistics are a result of education and the increased awareness that results from it, rather than from any practical measures.

The situation in Auckland is in stark contrast to that which exists in Waikato, where there has been no educational campaign and resources are difficult to access. All of the organisations checked for this research would be in contact with both parents and children of varying ages and at different periods in their lives under diverse circumstances, though only one (Plunket) had educational material on driveway runovers available. We note however, that none was involved in child accident prevention as their first or only activity. Indeed, there are no organisations operating in Waikato that are engaged primarily in child accident prevention.

Our Recommendations

Human factors

We found during this research that educational resources exist, but they are not well utilised. The Waikato region currently lacks ready access to the types of educational resources that exist in Auckland and there is no consistent programme or strategy to raise levels of awareness of driveway risks amongst the community. Ideally, the resources should reach the parents of young children prior to and during the child's preschool years. A number of opportunities for disseminating information on the risks of driveway runovers exist.

Initially education and resources could be incorporated into antenatal classes, though the message is likely to be lost amongst the avalanche of new information that is presented prior to the birth of a child. Reminders about the dangers of driveways are probably more useful to parents whose children are currently toddlers and preschoolers. Therefore it makes sense to utilise key points in child health care and development to provide preventative resources. For example, most children receive

an immunisation at eighteen months of age. This would be an ideal time to receive a pamphlet about driveway runovers. Similarly, when children graduate from infant's car seat to a booster seat another opportunity arises, particularly if the family is using the Plunket society's car seat scheme. Perhaps the most consistent means of disseminating resources would be to establish regular campaigns in kindergartens and preschools so that families receive reminders from their children at least twice a year. Another possibility involves the agencies involved in housing rentals and sales. For example, in 2006 the real estate company Barfoot and Thompson provided household safety literature to new home buyers in Auckland. As previously noted, there is an already established and comprehensive pool of information available to the public from Safekids NZ.

We recommend that Safekids' resources are better utilised beyond the Auckland region, through their strategic inclusion at key points in the families interaction with child development, health and educational agencies.

Vehicle factors

Vehicles fitted with reversing cameras score the highest on the State Insurance reversing visibility index and are endorsed by Safekids NZ. The price of reversing cameras has decreased from approximately $1000 several years ago to about $550 fully installed today. While this makes them much more affordable, we recognise that the cost will still be prohibitive for many families. We do not consider that the cameras are a suitable option for government subsidy, since families can change their cars relatively frequently as the family grows and the cameras themselves could be targeted by thieves. They also rely on the driver's attention being focused upon a screen in order to be an effective aid in the prevention of runover accidents. The existence of a camera does not guarantee its correct use. None-the-less, more models of new vehicles now come equipped with reversing cameras and the opportunity exists for government to require that all new vehicles have them fitted on the factory floor. We would endorse such a move, but note that the cost would be passed on to families and again we stress that effective use is dependent on driver attentiveness.

The use of reversing sensor technology has seen changes that may have improved their performance in recent years and we endorse those models which confine the audible alert to the interior of the vehicle. This avoids the problem of children being attracted to the beeping noise as the vehicle reversed. While there are advantages to the types of sensors on which the beeping increases in frequency as you move closer to the object, the sensors pick up any and all objects and it is likely that the constant noise will ultimately be ignored by drivers. Drivers must also remember that keeping the sensors clean is vital to the device working effectively.

Environmental factors

Stainless Steel panels

While we endorse convex mirrors as a practical means of addressing blind spots in driveways, their high cost is problematic and stainless steel reflective panels present a more affordable alternative.

We recommend that government investigate installing these panels on all state owned residential properties where there is a blind spot for turning vehicles.

Fencing

Fencing remains the most efficacious method of prevention. Where children are effectively isolated from the driveway there exists no possibility of harm. Current regulations apply only to modern housing however, and there is no requirement for older properties to conform to the relevant standard.

We recommend a review of the building regulations governing the area in and around residential driveways with a view to updating the Vehicle access standard NZS 4102:1996 to include shared driveways and apartment complexes.

Kidcatcher

The Kidcatcher provides an easy to use means of separating the driveway from the play area and/or house entrance to keep children away from the driveway in times of high vehicle use. As a physical and visual barrier, it serves both drivers (as a reminder of the presence of children) and caregivers (because it prevents children accessing the driveway) and is able to be adjusted to suit a variety of property configurations.

We recommend the Kidcatcher and advocate that a New Zealand agent is established to supply the devices more readily than is possible at present.

The virtual fence

Although more expensive than the Kidcatcher, a virtual fence may be a good alternative on properties that are not suitable for a Kidcatcher or when visual or audible warnings are desired. Because it is portable it can serve a family on multiple properties without the expense and impracticability of installing permanent fencing. Its present industrial applications suggest that there may be benefits to be gained from investigating ways to customise it for domestic use.

We recommend the virtual fence as a viable option for properties needing to separate the driveway from children's play areas.

We also recommend that a low interest loan is made available, if necessary, to families who wish to purchase a virtual fence.

We further suggest that all these environmental aids – the stainless steel panels and fencing alternatives – be promoted in educational resources directed at families.

Data Collection

Good data collection is one of the most important elements of attempts to address safety issues such as this. It is also essential if we wish to monitor the effects of interventions. We applaud the establishment of the Midland Regional Trauma System and its counterpart in Auckland. We stress the importance of establishing comprehensive standards for the coding of all categories associated with accidental injuries. This will facilitate future research by ensuring that there is one standardised code for an accident, such as a driveway runover, as well as providing clarity about associated variables.

We recognise that variations will still occur in data recording, if only because different individual will be involved in the recording at different times and in different places. These types of variations however, will be significantly less confounding than those associated with disparate and inconsistent data collection.

We recommend the extension of the trauma registry system to all regions in New Zealand.

Conclusion

Driveway runovers do not account for a high proportion of child deaths and injuries each year, though there has been a spate of them over the course of this research. While they are not common, they are totally preventable and it is our hope that this research contributes not simply to a reduction in driveway runovers, but to their complete elimination. While improvements in residential property design and the addition of new technologies to cars can go some way towards reducing driveway runovers, these are no substitute for vigilance. Ultimately, drivers and caregivers need to be constantly aware of the risks driveways present to children. This awareness can be fostered in dedicated educational campaigns and materials, but the mere existence of these resources is not enough. Regular, widespread dissemination is essential.

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Appendix 1

Summary Accident Data from all sources

Trauma Registry

Age	<1	2	3	4	5	6 to 8	8 to 15	Total
	5	1		1	1			8
Gender	Male	Female						
	5	3						
Ethnnicity	NZ Maori	NZ European		Polynesian		Other		
	7	1						
Type of vehicle	Car	Van	Truck	SUV	Unknown			
	3		1		4			
ISS	0 to 10	11 to 20	21 to 30	>30				
	5	2	1					

Media Injuries

Age	<1	2	3	4	5	6 to 8	8 to 15	Total
	2							2
Gender	Male	Female						
	1	1						
Ethnicity	NZ Maori	NZ European		Polynesian		Unknown		
						2		
Type of vehicle	Car	Van	Truck	SUV	Unknown			

Media Fatalities

Age	<1	2	3	4	5	6 to 8	8 to 15	Total
	1	1						2
Gender	Male	Female						
	1	1						
Ethnicity	NZ Maori	NZ European		Polynesian		Unknown		
						2		
Type of vehicle	Car	Van	Truck	SUV	Unknown			
		1						