Non-motor vehicle related pedestrian injury on and near the road – Implications for the Safe System approach to road safety

Frith,W. J. and Thomas, J.
Opus International Consultants, Central Laboratories, Wellington, New Zealand

Abstract

Research carried out from 2008 to 2010 examined the quantum and causes of non-motor vehicle injuries to pedestrians, on or near the roadway, through a structured interview survey. Under a Safe System approach these injuries are the responsibility of the Road Controlling Authority. The highest proportion of trips and falls (34%) were sustained while stepping over a kerb. Factors which amplified the severity of injuries included the road or path surface, pedestrians' inattention, type of footwear worn, and whether walking or running. Two main issues were identified from the study. These were that: 1) people tripped and fell more often on poorly-maintained surfaces as opposed to poorly-designed areas; and 2) the severity of the injuries is directly related to the surface. The study recommends improving the definition of kerbing in key pedestrian areas and improving the maintenance regime of footpaths and roads used by pedestrians, including crossing points. It also recommends making areas used by pedestrians more predictable in design. The study also found that there is a need to instigate research to provide improved data and analysis tools to allow Authorities to prioritise such countermeasures vis-à-vis other uses of road safety funds, and for improved data for input into such analysis tools.

Keywords

Pedestrian, injury, non-motor vehicle

Introduction

Walking, as an active transport mode, is being encouraged by both the Australian and New Zealand Governments as part of a push towards safe sustainable transport. It is important for the future growth of walking that the public has confidence in its ability to engage in this behaviour safely on the street network. This means putting effort into identifying under what circumstances pedestrian injury events occur, and hence to instigate effective mitigation measures.

Australia and New Zealand have a Safe System approach to road safety under which Road Controlling Authorities (RCAs) have a responsibility to minimise injury on their road networks, irrespective of whether or not the injury involves motor vehicles. Their networks include the roadway and areas near the roadway used by pedestrians. Thus the responsibility to mitigate pedestrian injury falls upon the RCA.

Most pedestrian injuries involve no motor vehicle and are therefore not reported as part of traffic crash data. The Accident Compensation Corporation (ACC) is New Zealand's publicly owned no-fault personal injury insurance provider. Approximately 30 000 pedestrian injury claims are made to the ACC per year, yet around 90% do not involve a moving motor vehicle. Of the approximately 2 600 more serious entitlement claims per year, around 80% do not involve a moving motor vehicle[1]. In New Zealand around 700 pedestrians are admitted to hospital each year due to slips, trips and stumbles in the road

[1] These numbers are from the analysis of data provided by the ACC. The claims we have considered are labelled 'pedestrian' and for this purpose are claims for which, on the ACC claim form, the scene of the accident was described as "road" and no moving motor vehicle was involved.

environment. This is similar to the 738 pedestrians admitted for injuries caused by motor-vehicle collisions in the 2008 calendar year.

As in New Zealand, non-motor vehicle pedestrian injuries in Australia are classed as falls on highways and streets. This covers a wide variety of circumstances including trips, slips and collisions with obstructions. According to Berry and Harrison (2007), in 2003-2004 there were 4 587 hospitalisations in Australia due to falls classified as "on street or highway"[2]. This is 72% greater than the 2 666 pedestrian hospitalisations associated with motor vehicles.

The US Department of Transport (FHWA, 1999) describes a project where data was collected prospectively at eight hospital emergency departments over approximately a one-year time period in three States: California, New York, and North Carolina. Information was gathered on 2 509 people treated for injuries incurred while bicycling or walking – 64 percent of the reported pedestrian injury events did not involve a motor vehicle.

There is a lack of knowledge about the circumstances and mechanisms of pedestrian injuries, particularly how they relate to infrastructure. This is a state of affairs needing to be remedied if we are to fully achieve the potential of walking as a serious mode of transport. Before any systematic remedial action can be taken, the infrastructural impediments to walking on New Zealand roads and roadsides need to be documented. This project seeks to remedy this lack of knowledge, using analyses of data related to the circumstances surrounding ACC claims for pedestrian injury occurring on or near the road, where motor vehicles were not involved.

Thus non-motor vehicle related pedestrian injuries sustained on the road networks of RCAs form a very important component of the overall burden of road network-related pedestrian injury. However, they are seldom considered by road safety practitioners and are generally not present in road safety strategies. This is a matter of concern, particularly when walking is being encouraged by governments who tend to ignore it in their road safety strategies.

Why is this so and how can it be remedied? Firstly there is no overt intention on the part of jurisdictions to ignore this injury burden. Rather there is a culture, ingrained over many years, that the set of injury events which road safety practitioners seek to prevent are those involving motor vehicles. This culture is, of course, not in line with the safe system approach which recognises all injuries related to the road network, so there is a need for change.

This paper attempts to move in that direction by seeking to remedy a lack of knowledge about the circumstances and mechanisms of non-motor vehicle-related pedestrian injuries, and particularly how they relate to infrastructure. Such knowledge is a prerequisite for both effective systematic remedial action regarding infrastructural impediments to safe walking on roads and roadsides and for new walking environments to be provided with effective levels of built-in safety. This is done by analysing data related to the circumstances surrounding ACC claims for pedestrian injury occurring on or near the road, where motor vehicles were not involved.

Methods

The ACC keeps records of pedestrian injury claims. From these records we are able to extract claims not related to motor vehicles. It is known that much information on the circumstances of the injury is not held by the ACC. This includes information about the geographical location of the injury event, the infrastructure involved and its condition, time of day, lighting etc. To get this information accurately

[2] In this study of ACC claims, around 25% of claims which appeared initially to be associated with roads and roadsides were found not to be so associated. We do not know how many hospitalisations classified as "on street or highway" were not so associated.

enough for it to be useful a home interview survey of injured people was required. This research involved the undertaking and analysis of such a survey. The project involved sample survey design questionnaire design, piloting and carrying out the survey

Non-motor injuries include those produced by such events as trips, falls, knocks and collisions with obstacles. In the health sector these events are often classified under the general area of falls. Two sources of information and data were used, namely: ACC claims for pedestrian injury occurring on or near the road, where motor vehicles were not involved; and a structured survey using face-to-face interviews of pedestrians injured on roads or footpaths and other roadside areas.

The home interview survey for this project was carried out at dwellings in urban areas around the Wellington region. The urban form in the Wellington region was considered sufficiently typical of New Zealand urban areas to generalise well to the rest of the country.

The sample universe was all non-motor vehicle related pedestrian injuries occurring near or on urban roads or streets, to people residing in areas under the jurisdiction of the road controlling authority. Those who were injured by other mechanisms or in other settings were excluded from the study, including those injured in accidents that did not occur on or near a road, such as accidents that occurred on a walking track, park or golf course. Rare events that were deemed outside the scope of this study were also removed, including mugging or sudden physical disability (such as muscle cramp).

Collisions with other pedestrians and cyclists remained in the sample. For the purpose of this research pedestrians include those using rollerblades, push scooters, skateboards and mobility scooters. Roadways included footpaths, grass verges, traffic islands etc. The geographical area for sampling was confined to those parts of the territorial local authority areas of Wellington City, Lower Hutt City, Upper Hutt City, Porirua City and Kapiti District which lie within main urban areas (MUAs) as defined by Statistics New Zealand.

The intended sample frame was all ACC claims related to relevant injuries to people living in those areas with accidents in the period December 2008–May 2009 inclusive. In actuality, a few people from earlier months were also in the sample supplied by the ACC and these were included. There were also a small number of injuries which happened elsewhere in the country to people in the sample. These were included if they occurred in urban areas. There are no population delimiters, apart from being able to communicate in person with the interviewer. Proxies for children and interpreters were permitted.

The sample was predominantly female and of European descent, which was not a response bias to the survey as the full sample of Wellington region injuries provided by the ACC was 61% female. The New Zealand Household Travel Survey (from 2003 to 2009) shows that, in main urban centres, females make about 30% more walking trips and spend 25% more time walking than men, so it follows that female accident frequencies would be expected to be higher due to greater exposure to walking.

Survey participants ranged in age from toddlers, where the parent present at the time of the accident undertook the interview, to elderly pedestrians (97.5 years), with an average age of 52 years. Figure 1 shows that the ages of pedestrians injured are relatively evenly distributed but with a perceptible bulge out towards older age groups. It is instructive to note that the percentage of this sample 64 and over is around 29% while the estimated New Zealand population percentage 65+ is 12.8%[3].

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[3] Derived from Statistics New Zealand December 2009 population estimates
http://www.stats.govt.nz/browse_for_stats/population/estimates_and_projections/NationalPopulation*Estimates_HOTPDec09qtr.aspx

Figure 1: Histogram of participant age in years, taken from the time of the accident

Results

Injuries per million hours walked

Non-motor vehicle pedestrian injuries[4] in New Zealand main urban areas, per million hours spent walking, by age, are outlined in Figure 2. Figure 2 also compares these statistics with passengers, driver and pedestrians killed or injured in New Zealand urban Police reported motor vehicle crashes by age. New Zealand Household Travel Survey data provided the average annual walking exposure levels age using data from July 2003 to June 2009. In all cases, once middle-age is reached, the injury rates tend to increase with age. This is in line with what is generally found when exposure-related risks from activities are tabulated against age[5]. Future demographic change will result in a steady increase in the number of older people. Thus, the increased rate with age indicates that absolute numbers of injuries in this age group are likely to increase substantially, with predicted increases in older age groups, [6]as the population

[4] These relate to injuries associated with the road and roadside

[5] These rates are quotients of estimates made using assumptions which are approximate. However, the general direction of the results in Figure 2 has validity and provides useful information. An assumption not otherwise mentioned relates to the fact that travel survey data are annual while the ACC data used covered the six-month period of December 2008 to May 2009 inclusive. In order to estimate an annual rate the numbers of accidents were simply doubled.

[6] See http://www.stats.govt.nz/reports/papers/demographic-aspects-nz-ageing-population.aspx as a typical example

of New Zealand ages, unless countermeasures can be developed. How this will affect the overall burden of pedestrian injury is outside our scope.

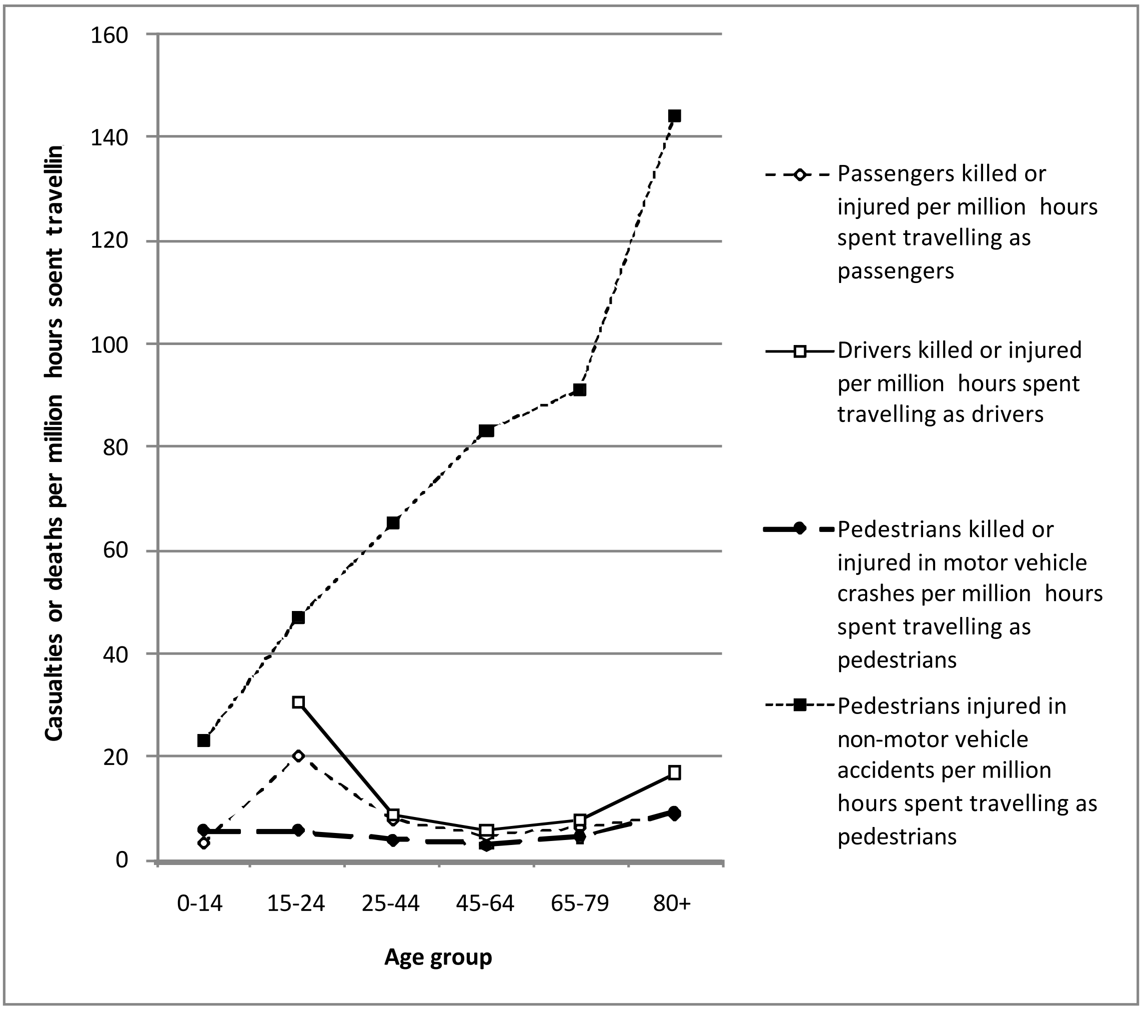

Figure 2: New Zealand main urban area pedestrian injuries not involving motor vehicles, per million hours spent walking, by age, compared to passengers, driver and pedestrians killed or injured in urban[7] motor vehicle crashes by age

Figure 2, when used to compare non-motor vehicle pedestrian injuries per million hours spent walking, with dead and injured passengers, pedestrians and drivers per million hours spent travelling, from motor vehicle crashes, shows that these are reported in much greater quantities than motor vehicle injuries. For the 80+ age group the difference approaches an order of magnitude. How the severity of the injuries and their reporting rates compare could be the subject of another project.

[7] Vehicle trips were considered "urban" if the speed limit was 70km/hr or lower.

Location of non-motor vehicle pedestrian injury accidents

Accidents occurred more often on the roadside (79.8%) than on the road (20.2%). Figure 3, which depicts the percentage of accidents that occurred in different roadside locations, shows that roadside accidents mainly occurred on the footpath (80.2%), with a further 13.8% of accidents occurring due to a vertical change in the pedestrian's path (due to either a kerb [10.7%] or steps/ramp [3.1%]).

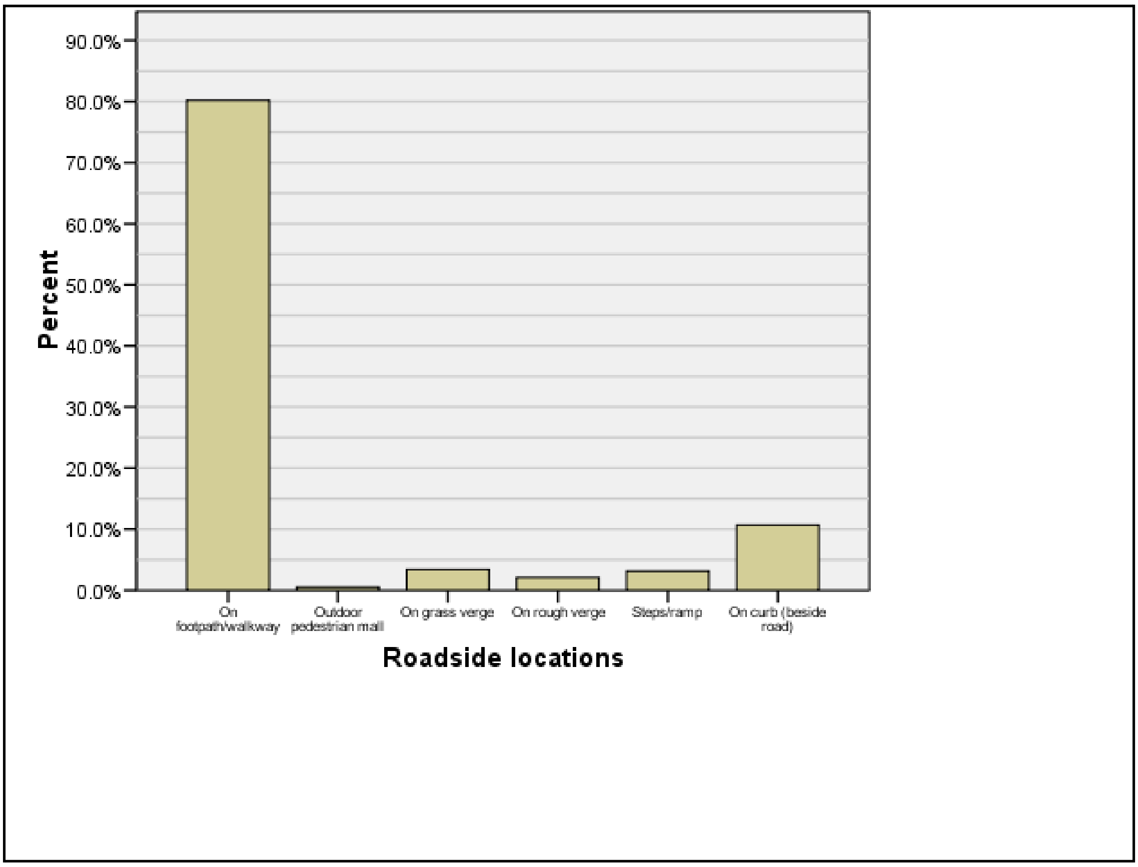

Figure 3: Percentage of accidents that occurred in different roadside locations

Environment/infrastructural factors

Environments must be designed to account for the fact that pedestrians are often obstructed visually, physically impaired, fatigued, or simply distracted. Fothergill et al, 1995 found that two-thirds of falls in public places occurred on pavements, and about 50% of falls involve uneven surfaces underfoot or inadequate street lighting. About 8% of pedestrians reported poor lighting as a contributing factor in their accident, whereas vertical changes and uneven surfaces were more commonly reported hazards.

The survey has shown that vertical changes, in particular kerbs, are a key cause of pedestrian trips and falls. Misjudging the kerb height when stepping down is likely to be more forgiving than tripping on the edge of the kerb when stepping up. Also, pedestrians are more likely to pause before stepping down from a kerb on to the road. Whatever the explanation, a design solution to make the vertical change more visually obvious would be beneficial, as would more consistent kerb heights.

There is a particular problem with safely negotiating a walking environment when there is a disparity between the perceived predictability of the environment and the actual continuity of the environment. For example, when pedestrians negotiate steps they predict that each step will be evenly spaced unless there is visual information to say otherwise[8]. Ayres and Kelkar (2006) suggest that the key reasons we fail to recognise trip points include: a narrow gaze direction; distraction (e.g. mentally distracted or engaged in an activity); attention impairment (e.g. alcohol, fatigue); underestimation of risk; and "change blindness". The theory of change blindness suggests that pedestrians do not detect large changes in their environment unless they are actively attending to them (Jovancevic et al., 2006). Thus predictability of the environment is important to pedestrians, as it is to motorists.

Figure 4 shows the different types of obstacles that contributed to an injury. The rate of on-road accidents with no obstacle was slightly higher (19.2%) than that of roadside accidents with no obstacle (16.8%). Again, the kerb was a greater hazard for on-road users where they would be required to step up, when compared with those stepping down on to the road.

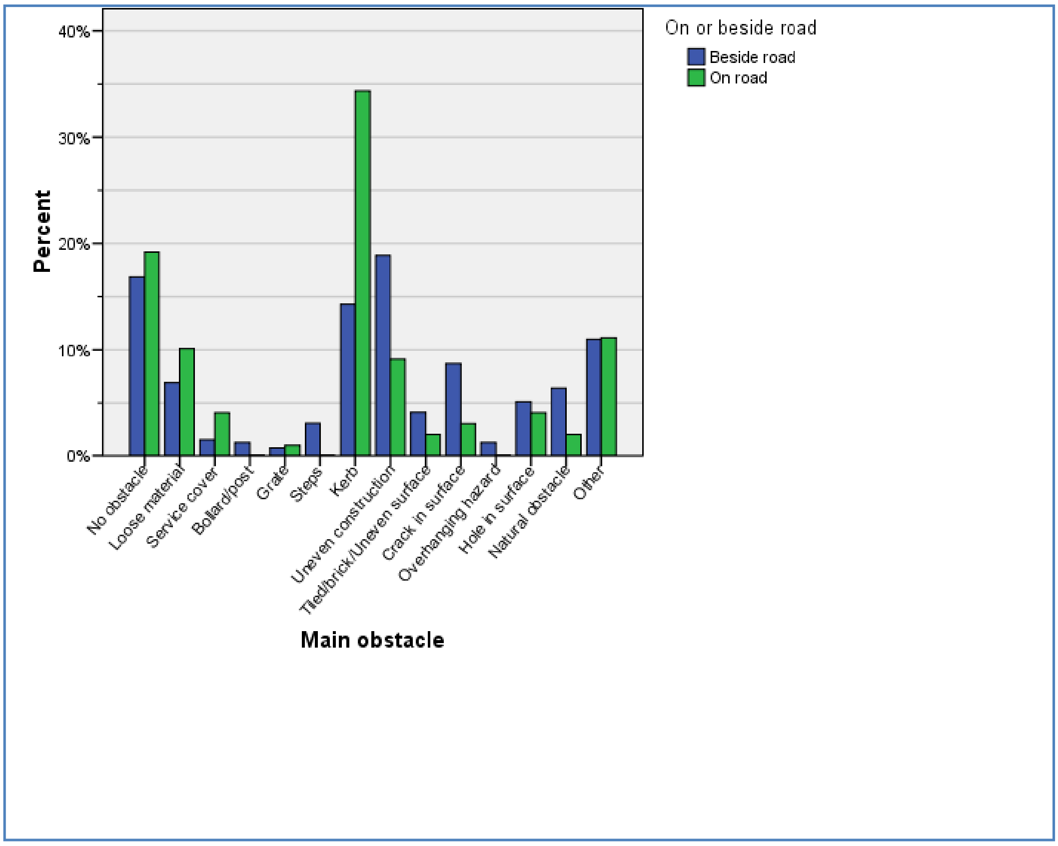

Figure 4: Percentage of accidents caused by different obstacles on and beside the road

Uneven construction was the most commonly reported hazard type in roadside pedestrian accidents. The most common surface type pedestrians slipped, tripped or fell on (Table 1) was asphalt/bitumen, followed by concrete, most likely due to a high exposure to these surface types.

[8] This is a similar concept to a self-explaining road

Surface	Frequency	Percent
Asphalt/bitumen	165	37.1
Chip seal	30	6.7
Concrete	152	34.2
Grass	14	3.2
Tiles/pavers/bricks	53	11.9
Tactile pavers	3	.7
Loose gravel	19	4.3
Other	9	2
Total	**491**	**100.0**

Table 1: Frequency of accidents by the surface material slipped, tripped or fell from[9]

Lighting

Accident locations were primarily well lit (86.2%), with sunlight as the typical light source (81.5%). At accident locations having artificial lighting at the time of the accident the lighting was predominantly judged as poor by respondents. The walking environments of well-lit areas were rated better in terms of the design compared with those of poorly-lit areas. People were also less likely to see hazards in poorly lit environments.

Compliance of accident sites with basic pedestrian service criteria

A sample of 14 accident sites was examined to determine whether the sites complied with basic pedestrian level of service criteria. The New Zealand Pedestrian Planning Guide (Land Transport New Zealand, 2009) was used to help determine site standard compliance. All sites had unsatisfactory accident related characteristics, both from expert opinion and, in seven cases, also in relation to the Pedestrian Planning Guide criteria.

Injury types

Of the injuries sustained (Table 2), 43% were sprains and strains. Serious injuries, such as fractures, accounted for between 12% and 15% of injuries. Less than 3% of injuries were to the head.

[9] This table excludes accidents not classified, for the purposes of this paper, as a slip trip or fall. Not slip trip or fall includes accidents such as hitting head on a tree, being knocked over by another person, and accidents at change points such as the kerb.

Injury type	N	Percent
Sprain/strain	205	43.25%
Laceration/puncture	74	15.61%
Contusion	69	14.56%
Fracture/dislocation	59	12.45%
Other	67	14.14%
Total	**474**	**100%**

Table 2: Frequency of pedestrian injury types

Pedestrian characteristics

Pedestrians typically agreed (87%) that they were physically fit, with only 3% reporting they were suffering from an illness, and 4% reported they were suffering from a previous condition (injury/frailty/sickness) at the time of the accident. Approximately 45% of participants agreed or strongly agreed they had some level of distraction at the time of their accident. People mostly wear appropriate footwear, are familiar with the environments in which they are walking, are physically fit and not typically looking at their feet as they walk.

Footwear

An examination of footwear by location reveals that less stable footwear, such as medium and high-heel shoes tend to be used in the CBD. High-heel wearers were more likely to report that they were travelling too fast for the walking surface when compared with those wearing flat-soled or running shoes. In the sample group, those pedestrians wearing high heels at the time of the accident tended to report that they were travelling too fast for the surface. There is already evidence that higher heels do not reduce women's walking speeds in New Zealand. These pedestrians are often in the CBD, wearing work clothing and walking for work purposes, which has been shown to relate to higher walking speeds than, say, walking for other activities such as leisure or shopping (Finnis and Walton, 2008). The combination of faster walking speeds with less stable footwear should be taken into account when designing high-pedestrian traffic CBDs.

Responsibility and prevention

Survey participants were separately asked "what was the one main contributing factor with the best chance of preventing the accident?" and "who is mainly responsible for the accident?" Participants primarily had an internal locus of control, placing the responsibility for the cause of the accident and accident prevention on themselves. A total of 249, or 51%, considered themselves to have had the best chance of preventing the accident and 185, or 38%, considered themselves the main factor responsible for the accident. Seventy-six people took personal responsibility for accidents when they actually believed the main mechanism of prevention for the accident related to better maintenance (n = 36), better design (n = 30) or another person (n = 10). There are a further 12 people who believed they could possibly have prevented the accident, but also blamed the maintenance (n = 6), design (n = 3) or another person (n = 3) as other factors increasing their risk. With the public tending to consider themselves the major cause of their injuries, they are less likely to complain about infrastructure defects than if they were more alert to the role of the infrastructure.

Complexity of non-motor vehicle pedestrian injury accidents

The causes of a pedestrian slip, trip or fall are typically complex and certainly not solely a function of the environment. People have strategies to compensate, and adjust to walking through untenable walking environments. Even when people encounter obstacles as high as a bathtub while they are wearing low-traction footwear they ably negotiate the obstacle without falling, as they are attentive to this difficult walking environment (Decker, 2009).

Walking through an environment is a relatively simple task, but there are often additional factors that can increase the complexity of this task. The survey indicates that people carry loads, engage in other activities (9%), or hurry through their walking environment (29%). These factors can block their vision, distract them from their task and alter their gait. Therefore, environments that are not forgiving to pedestrians that may be fatigued, visually impaired or distracted are more likely to cause accidents than those which are more forgiving.

The complexity of pedestrian accidents is heightened when cognitive factors are included, such as a relatively low perception of risk and low attentiveness. In this study, about 45% of pedestrians reported some level of distraction at the time of their accident. Leclercq and Thouy, 2004 also conclude that accidents do not happen in isolation from other factors, such as preoccupation with events not related to walking.

Summary of issues

Infrastructure/environment related

- Kerbs (vertical changes) are a major contributory factor in pedestrian trips, falls and injuries, particularly when stepping up (as opposed to down).
- Maintenance is more of an issue than initial design and construction.
- The site visits suggest that places where accidents occur tend to be rated unfavourably by experts vis-à-vis the part of the infrastructure associated with the accident. They also tend to have one or more faults that violate design standards in the relevant NZ guide.
- Environments that are not forgiving to pedestrians, which may be fatigued, visually impaired or distracted, are more likely to cause accidents.
- Uneven construction is the most commonly reported hazard type in roadside pedestrian accidents.
- Environments ought to be predictable to the pedestrian (“no surprises”).
- The combination of faster walking speeds with less stable footwear (e.g. high heels) should be taken into account when designing high-pedestrian traffic areas. This is in accordance with safe system principles.

Person-related

- People primarily internalise the responsibility for walking accidents, rather than finding fault with the infrastructure, even when the infrastructure is clearly a large contributing factor to the accident.
- People that believed they were travelling too fast were more likely to take responsibility for their accident than other people, again even when the infrastructure had an important role in the accident.
- These views on the part of pedestrians could compromise the reporting of infrastructure defects to the authorities.

Future related

With predicted increases in the older population, vulnerable older pedestrians will be more numerous, which is likely, all other things being equal, to increase pedestrian injury.

Conclusions

- The Safe System approach to road safety demands that Road Controlling Authorities have a responsibility to minimise injury on their road networks (including areas near the roadway used by pedestrians), irrespective of whether or not the injury involves a motor vehicle.
- This research, and previous cited research, shows that pedestrian injury not related to motor vehicles contributes significantly to road trauma numbers. However, there are serious impediments to carrying out systematic work to improve the situation.
- These impediments relate to the fact that the types of pedestrian injury sampled in this study do not feature in our database of road crashes which includes only motor vehicle-related crashes. This has the effect of placing them generally "below the radar" of those engaged in road safety work, whether that be locally or centrally.
- The absence of this information from the crash database also makes monitoring their incidence, and the setting of performance measures, more difficult. There are no "quick fixes" for these data problems, but the use of the relevant National Health Statistics and insurance data for monitoring purposes could help to fill the gap.
- In New Zealand, the main publication where these pedestrian injury incidents are highlighted is the LTNZ Pedestrian Planning Guide, which would arguably have lower than optimal penetration into the road safety community.
- In order to achieve better levels of penetration, these injury incidents should be recognised as an integral and important part of road safety, and their prevention should be consciously and deliberately brought into the road safety mainstream as an area for targeting by countermeasures under the safe system approach.
- The first steps in this approach could be the promulgation of a policy that, at the local regional and national levels, all road safety strategies, safety management systems and associated action plans should specifically have regard to these injury events, on a level playing field with motor vehicle crashes.
- The promulgation of such a policy would have the inevitable consequence of stimulating a demand for improved analysis tools to prioritise such countermeasures vis-à-vis other uses of road safety funds and improved data for input into such analysis tools.
- It is to be expected that the major focus of such countermeasures would relate to those direct infrastructure issues described in this paper, although there may be some scope for behavioural countermeasures in conjunction with the wider injury prevention community.

Recommendations

It is recommended that the decision making bodies of the Australasian road safety community:

- Formally recognise the prevention and mitigation of non-motor vehicle pedestrian injury as an integral and important part of road safety.
- Bring the prevention and mitigation of pedestrian accidents consciously and deliberately into mainstream road safety activities.
- Promulgate a policy that, at local, regional and national levels, all road safety strategies, safety management systems and associated action plans should specifically have regard to these pedestrian injury events.
- Instigate research to provide improved data and analysis tools to prioritise such countermeasures vis-à-vis other uses of road safety funds and improved data for input into such analysis tools.
- Commission a guide for pedestrian road safety audit and inspection covering both motor vehicle and non-motor vehicle risk.

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References

Ayres, T.J. and Kelkar, R. (2006). Sidewalk potential trip points: A method for characterizing walkways. International Journal of Industrial Ergonomics, 36, 1031-1035.

Berry J.G. and Harrison, J.E. (2007). Hospital separations due to injury and poisoning, Australia 2003–04. Injury research and statistics series no. 30. AIHW cat. no. INJCAT 88. Adelaide.

Finnis, K. K., & Walton, D. (2008). Field observations to determine the influence of population size, location and individual factors on pedestrian walking speeds. Ergonomics, 51(6), 827-842

Fothergill, J., O'Driscoll, D. and Hashemi, K. (1995). The role of environmental-factors in causing injury through falls in public places. Ergonomics, 38 (2), 220-223.

Jovancevic, J., Sullivan, B. and Hayhoe, M. (2006). Control of attention and gaze in complex environments. Journal of Vision, 6, 1431–1450.

Leclercq, S. and Thouy, S. (2004). Systemic analysis of so-called 'accidents on the level' in a multi trade company. Ergonomics, 47 (12), 1282-1300.

Land Transport New Zealand (2007). Pedestrian Planning and Design Guide. Wellington. Sourced from: http://www.nzta.govt.nz/resources/pedestrian-planning-guide/design-pedestrian-network.html Viewed 17 June 2010

US Department of Transportation, Federal Highways Administration. (1999). Injuries to pedestrians and bicyclists: an analysis based on hospital emergency department data, USA. Sourced from http://www.tfhrc.gov/safety/pedbike/research/99078/99-078.htm Viewed 17 June 2010.