UNDERSTANDING PEDESTRIAN SAFETY IN NEW ZEALAND

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ABSTRACT
The number of people killed or seriously injured on New Zealand's road network has fallen over recent decades. However, there has been no meaningful change in the number of pedestrian fatalities over the last ten years. Although the safe system approach to road safety recognises that people make mistakes and are vulnerable, the main causal factors in pedestrian crash reports essentially blame the pedestrian for crossing the road, with codes such as "poor observation" and "crossing heedless of traffic". In the context of motor vehicle crashes, human factors are leading to systemic changes in the way that we design safe and forgiving environments, with a particular emphasis on speed management. Unfortunately, there are not many initiatives to reduce the pedestrian death toll directly. This paper presents an investigation into and analysis of pedestrian deaths, serious injuries and hospitalisations between 2006 and 2015. It identifies underlying systemic issues with the way that we approach pedestrian safety; where it is similar to safety for people in motor vehicles and where differences warrant different approaches. The results suggest that pedestrian safety deserves more prominence within New Zealand’s national road safety strategy. Practical prioritisation and analysis tools are presented that can help road controlling authorities improve safety and accessibility for all people on foot or using mobility aids, as we work towards safe sustainable environments to promote everyday walking.

1.0 INTRODUCTION

Walking is an important transport mode and is also the most popular recreational activity in New Zealand (Sport New Zealand, 2015). New Zealanders walk on average 52 minutes per person, per week (Ministry of Transport, 2015), and 5% of journeys to work are made entirely by walking. In addition, walking is a component of many journeys by public transport and private motor vehicle (Ministry of Transport, 2016a).

Despite the popularity of walking and its demonstrated health benefits (Hanson & Jones, 2015; Lee & Buchner, 2008), it is the lesser cousin of driving, and in recent years cycling, in New Zealand transport policy. Current national government policy objectives for transport are largely concerned with managing and mitigating congestion in urban areas, and reducing the social cost of road crashes. Providing ‘appropriate’ transport choices is also a national strategic objective, but regional and local investment is dominated by large road infrastructure projects, with spending on footpaths and road crossings largely contained to discretionary ‘minor safety’ and maintenance budgets (Ministry of Transport, 2016b).

The problems of traffic congestion and road trauma, and the benefits gained by addressing them, are largely contained within the transport industry, so associated projects can be prioritised nationally and within Territorial Local Authorities with clear appraisal methods. Furthermore, traffic volumes are typically measured and monitored extensively (see for example NZTA (2016) and Auckland Transport (2016)), so accident rates at specific locations on the road network can be calculated relatively easily. The volume of traffic and crash data collected and shared among jurisdictions internationally has meant that the road safety industry has increasingly sophisticated crash prediction models, enabling precise targeting of road safety investment to risk (Turner, Wood & Roozenburg, 2006; Qin, Ivan, Ravishanker, & Liu, 2005).

Unfortunately, pedestrian volumes on footpaths and road crossings are not typically monitored with anywhere near the detail of motor vehicle traffic on roads (Liu & Griswold, 2009; Montufar, 2015). Manual surveys are the most common count method and they are relatively expensive compared to automated vehicle counts. Another reason why pedestrian data is not often collected may be that pedestrians do not take up much space, so specific design for capacity is not usually necessary; and the design load for a footpath is uniform between city centres, residential suburbs and rural areas, so there is no equivalent of ‘heavy vehicles’ informing pavement depth or specification.

It is perhaps an unintended consequence of a lack of pedestrian volume data that there is no robust way to calculate prospective risk for pedestrians in any particular environment. Evidence for this lack of data is clear in New Zealand’s road safety assessment framework for urban roads, Urban KiwiRAP, which states that crash rates for urban intersections are calculated based on motor vehicle traffic because “As volumes of ARU (Active Road Users) across many parts of the transport network is unknown, only Collective Risk values are calculated” (KiwiRAP, 2016). Reported crashes are the only real clue as to where investment in pedestrian safety may be warranted.

However, there are important differences between walking and driving that must be made explicit if investment in walking safety is to be targeted to risk. Sealed roads are universally designed to allow travel by almost all motor vehicles. Traffic models attest that drivers of motor vehicles typically choose the most direct routes, in terms of time or distance. In contrast, footpaths and road crossings are not made equal. Pedestrians are humans and tend to cross roads according to their own subjective trade-off between risk and convenience (Seneviratne & Morrall, 1985). Therefore while motor vehicle drivers usually stay within kerbs, pedestrians are generally less inclined to cross at ‘formal’ locations (Evans & Norman, 1998; Holland & Hill, 2007). Equally, pedestrians can (and do) choose not to cross a road where they perceive it to be hazardous. They either cross somewhere else, or do not cross at all; that is, they do not make the trip (Burdett & Pomeroy, 2011). In contrast, safety is rarely an important factor in route choice for drivers (Papinski, Scott, & Doherty, 2009).

The flexibility of pedestrian route options, combined with a lack of data about where pedestrians are (and are not), means that reliance on the rare and random reported collisions between pedestrians and motor vehicles is a less than ideal way to assess risk.

One way to assess risk for pedestrians at specific locations is the traffic conflicts technique, which uses analysis of near-miss incidents and other behaviours to look at potential for collisions before they happen (Pin, Sayed, & Zaki, 2015). Although the traffic conflicts technique is a promising way to assess risk at particular locations, it takes more time and expertise than a simple manual survey, so it is generally only used to investigate site-specific problems. The locations where conflicts are assessed are not prioritised with data.

Therefore, there is a need to find more objective ways to prioritise investment in pedestrian safety. Pedestrian crashes are the outcome of an unsafe system, but their locations are not necessarily indicative of the most worthwhile places to invest in new or different infrastructure, because the lack of pedestrian volume data means there is no context for the crash numbers. The denominator in the calculation of crashes “per pedestrian” is missing.

It may be possible to look to the denominator in the crash rate equation to provide a more targeted investment in pedestrian safety. Volumes of pedestrians can give insight into relative popularity of different routes. However, there are two groups of pedestrians who are particularly sensitive to perceptions of safety and security, namely older people, and people with disabilities (Kirchner, Gerber, & Smith, 2008). Assessment of their route choice and behaviour may give more direct clues as to relative perceived risk, enabling a more objective and targeted investment in safety for all pedestrians.

This report presents an investigation into the data that tends to inform ad-hoc investment in pedestrian safety in New Zealand, arguing that an increase in targeted pedestrian counts could inform a more objective prioritisation of improvements. In particular, the case for counting the proportion of mobility aid users (as a subset of all pedestrians) is put forward as a useful tool in the ongoing quest to reduce the social cost of road trauma.

2.0 RESEARCH QUESTIONS

The research questions for this investigation are:
1) How are reported pedestrian fatal and serious crash numbers and hospitalisations changing over time in New Zealand?
2) What reported causal factors feature in Traffic Crash Reports related to fatal and serious crash outcomes for pedestrians?
3) Who are the most vulnerable pedestrians, and how do they choose whether and where to travel?
4) How can pedestrian volume data inform investment in pedestrian safety?

3.0 METHOD AND ANALYSIS

1) A descriptive summary of reported pedestrian crash and hospitalisation data.
2) Calculation of regression coefficients for trends in motor vehicle and pedestrian crashes over ten years.
3) A basic content analysis of causal factors in reported pedestrian crashes.
4) A case study of crashes in Hamilton City.
5) Qualitative analysis of a focus group of people with disabilities concerning their perceptions and use of footpaths and road crossings.
6) An investigation into the potential value of using pedestrian volume data to make inferences about perceptions of safety.

3.1 Pedestrian crash and hospitalisation data: Descriptive statistics and content analysis

A breakdown of the nature of pedestrian crashes with a fatal or serious outcome is shown in Table 1. In all cases, the injured road user was a pedestrian. There were 2,734 reported crashes with a fatal or serious outcome involving pedestrians from 2006 until 2015 (inclusive), resulting in 2,838 pedestrian casualties. Note that the totals in Table 1 do not necessarily reflect the sum of individual components due to differences in assigning causal factors between crashes.

The number of hospital-days stayed by pedestrians involved in road crashes, by age group, is shown in Table 2, as well as the overall numbers of people hospitalisd by age, from 2010 -2015 inclusive (Ministry of Transport, 2016). These data show that average number of days hospitalised increases markedly with age, from less than three days per injured pedestrian aged less than 15 years, to over 15 days per injured pedestrian aged 65 years and above.

Content analysis of the English-language crash listing revealed several repeated phrases in descriptions of crashes involving pedestrians. Common phrases and their frequency are listed in Table 3.

2006 - 2015	Fatal crash casualties	Serious Crash casualties	Total casualties	Percentage of all fatal/serious pedestrian casualties
All	355	2483	2838	
Age				
Number pedestrian aged under 15 years	38	556	594	21%
Number pedestrian aged 15-64 years	207	1289	1496	53%
Number pedestrian aged >64 years	105	418	523	18%
Light				
Number bright sun / overcast	163	1635	1798	63%
Number Twilight	12	77	89	3%
Number Dark	176	670	846	30%
Alcohol				
Number alcohol suspected, all pedestrians	91	215	306	11%
Alcohol, age <15	1	5	6	<1%
Alcohol, age 15-64	86	193	279	10%
Alcohol, age >64	4	7	11	<1%
Intersection / Midblock				
Midblock, all	248	1356	1604	57%
Midblock, age <15	26	354	380	13%
Midblock, age 15-64	160	753	913	32%
Midbock, age >64	61	187	248	9%
Intersection, all	103	1027	1130	40%
Signals	22	310	332	12%
Roundabout	3	36	39	1%
Driveway	21	211	232	8%
Priority T-intersection	56	484	540	19%
Posted speed limit				
100km/h	115	173	288	10%
60km/h - 90km/h	48	164	212	7%
50km/h	179	1900	2079	73%
<50km/h	9	143	152	5%

Table 1 Summary of pedestrian crash details, all fatal and serious injury crashes involving pedestrians, 2006 - 2015 (inclusive) (NZ Transport Agency, 2016)

Year	Number of people hospitalised			Total number of days in hospital		
	<15 years	15-64 years	65+ years	<15 years	15-64 years	65+ years
2010	167	404	108	431	1696	1988
2011	158	405	109	539	2047	1452
2012	120	390	115	315	1907	1951
2013	154	388	127	380	1963	1720
2014	150	170	108	407	1940	1938
2015	115	378	120	431	2748	1734
Average number of days in hospital per person hospitalised	2.9	6.3	15.8			

Table 2 Days in hospital, and numbers of pedestrians hospitalised by age, 2010 – 2015

Phrase	Frequency across 2,734 Reported Crashes	Proportion of all fatal/serious crashes mentioning phrase
"crossing"	1962	69%
"heedless of traffic"	1176	41%
"alcohol impaired non-driver"	306	11%
"did not see or look for other party until too late"	186	7%
"pedestrian wearing dark clothing"	184	6%
"unnecessarily on road"	159	6%
"child escaped from supervision"	71	3%
"walking on footpath"	68	2%
"intentional collision"	48	2%
"Car1 alcohol suspected"	32	1%

Table 3 Frequency of phrases within English Language Crash Listings from Crash Analysis System

The first point to note from the data in Tables 1 - 3 is that pedestrian casualties aged over 64 years are more likely to be killed or seriously injured if they are involved in a collision. These older pedestrians also have a much longer stay in hospital as a consequence.

In terms of infrastructure, the data also show that most crashes involve pedestrians crossing roads, including 42% “heedless of traffic”. Crossing the road results in a high number of deaths, injuries and hospital stays. A high proportion of crashes happen at midblocks, which includes crossing with no formal infrastructure as well as refuge islands and zebra crossings.

Almost three quarters of fatal and serious pedestrian crashes happen on urban roads, however the ratio of fatal:serious crashes is higher on rural roads. That is, if a pedestrian crash happens on a rural road, it is more likely that the outcome will be fatal.

3.2 Pedestrian crash and hospitalisation data: Linear regression

A subset of the reported number of people killed and seriously injured on NZ roads between 2006 and 2015 (inclusive) is shown in Figures 1 and 2. These data are shown separately for people involved in motor vehicle crashes (including light and heavy vehicles and motorcycles: no pedestrians or cyclists involved; Figure 1), and for pedestrians (Figure 2).

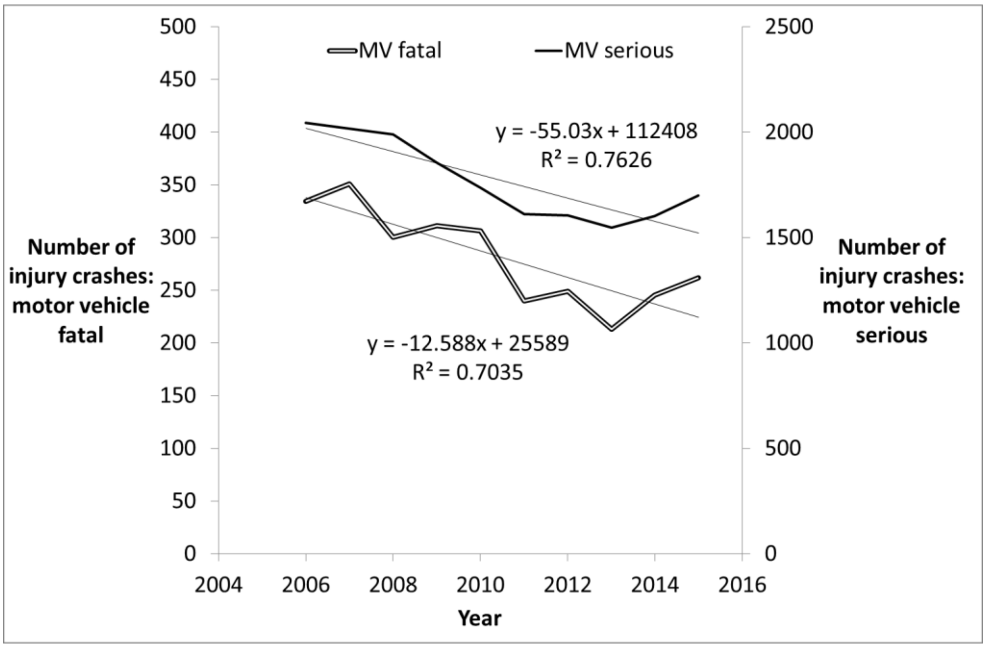

Figure 1: Reported motor vehicle crashes resulting in fatal or serious injury on New Zealand roads, 2006 – 2015 (inclusive)

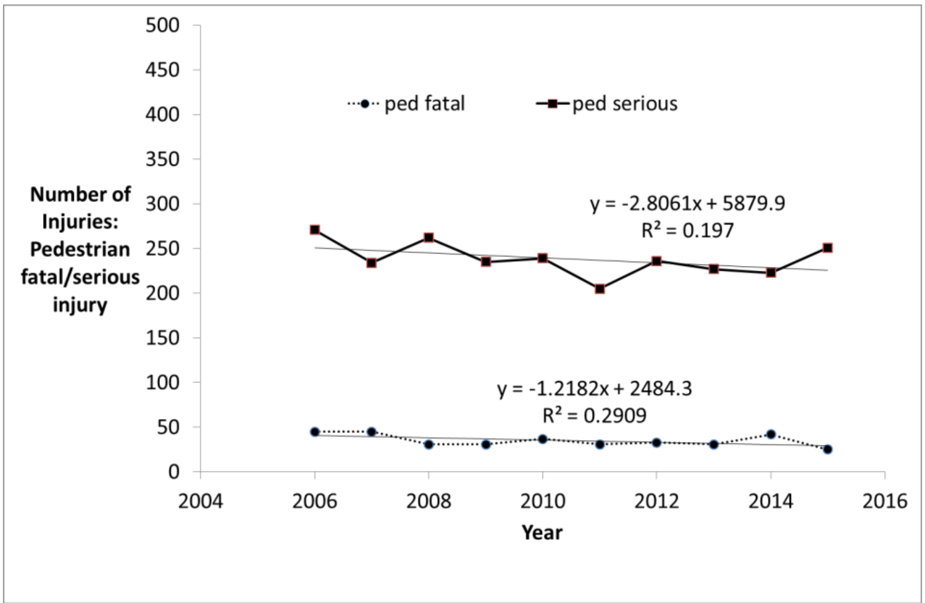

Figure 2: Reported crashes involving pedestrians, resulting in fatal or serious injury on New Zealand roads, 2006 – 2015 (inclusive)

The data in Figures 1 and 2 show that there are significant downward trends in fatal and serious crashes involving motor vehicles from 2006 to 2015, although the trend has stabilised over the last four years. There is no significant, corresponding trend for crashes involving pedestrians, with correlation coefficients less than 0.3 for both fatal and serious injury crashes involving pedestrians in the ten years to 2015.

Figure 3 shows trends in the amount of walking and reported fatal and serious pedestrian crashes for people aged 65 years and older. These data show that there is a significant downward trend in the amount of walking by people aged over 65 years, although the amount of walking fluctuates considerably. There is no significant trend of any kind related to reported fatal and serious pedestrian crashes involving people aged 65 years and older.

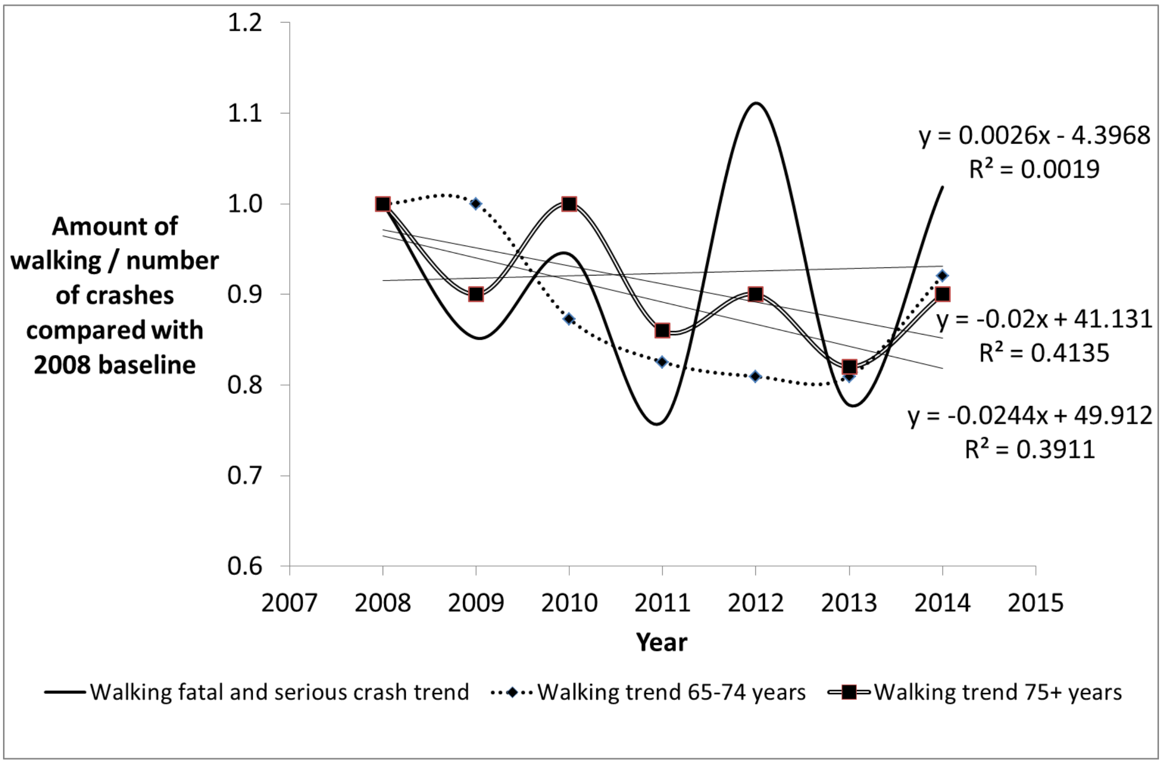

Figure 3: Trends related to walking and fatal and serious pedestrian crashes for people aged over 65 years

3.3 Case Study: Hamilton City Pedestrian Crashes

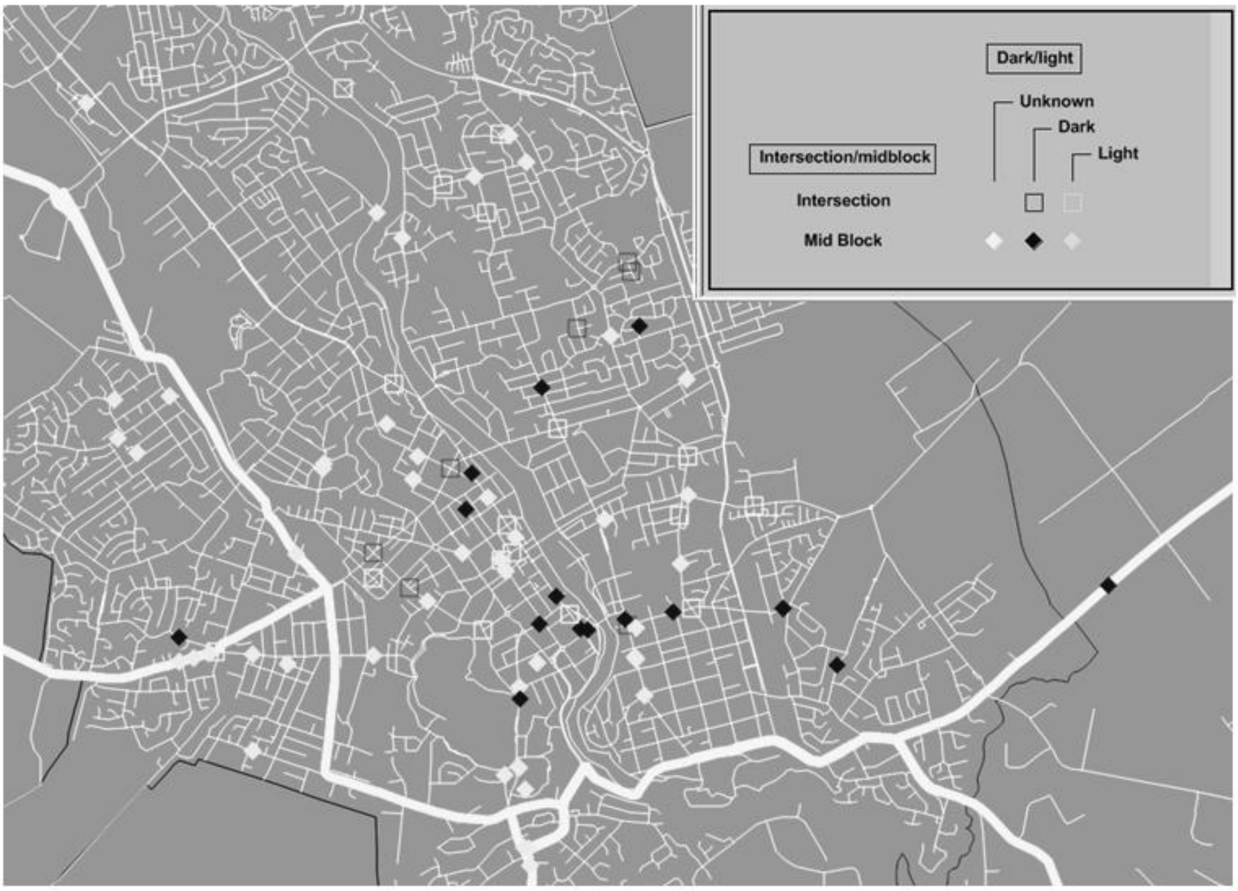

Figure 4: Subset of reported fatal and serious pedestrian crashes in Hamilton City, 2006 - 2015

The map shows that there are dozens of fatal and serious crashes involving pedestrians in Hamilton City, but few clusters. Hamilton data replicated the finding from New Zealand as a whole that crashes happen at intersections as well as mid-blocks, and many crashes happen in daylight with little in the way of obvious trends or common causal factors that can be addressed as a whole.

In the absence of comprehensive pedestrian volume information, these isolated crashes are difficult to address. Two recent incidents highlight difficulties inherent in planning for pedestrian safety in the absence of pedestrian volume data. These examples are based on observations of changes to infrastructure after the incidents concerned and are not a comprehensive analysis of decision-making by any organisations involved. They are presented as isolated examples as a contrast to the sophisticated data available for analysis of safety on roads, such as star ratings and associated maps provided to all practitioners and researchers by KiwiRAP (KiwiRAP, 2016).

The first example was a fatal collision between a car and a pedestrian on Victoria Street at the northern end of Hamilton's Central Business District, in May 2011. The Traffic Crash Report stated that the 91 year old woman crossed the four-lane arterial road north of the signalised intersection, between two bus stops on either side of the road. The woman was hit as she neared the western side of the road by a car driven with 'excessive' speed. After this incident, a refuge island was installed in the road median and a signalised mid-block crossing was added on a nearby intersection arm to improve access to the bus stop.

The second incident was a fatal collision between a car and a pedestrian at a relatively new mid-block signalised pedestrian crossing on Horsham Downs Road, in a residential suburb in the northeast of Hamilton. A 69-year-old woman was struck crossing the road by a car driven by an 88 year old man who failed to stop for a red light at the crossing. There was no specific change made to the crossing or surrounding road network after this fatal crash.

3.4 Qualitative Data: Focus Group

In 2015 a focus group was held with 7 members of the Hamilton branch of the Disabled Persons' Assembly. The focus group was part of a research project commissioned by the Road Controlling Authorities' Forum (Burdett, Locke & Scrimgeour, In Preparation). The purpose of the focus group was to talk with people identifying with disability, to understand more about how they value footpaths, and what factors affect their decision to undertake any particular trip as a pedestrian (with or without some mobility aid such as a wheelchair, walking stick or guide dog).

The main finding from the focus group was that for people with disabilities, personal safety is paramount and an explicit factor in decisions about whether and where to walk. Although many barriers in a journey as a pedestrian are unforeseeable (a typical example being barriers related to temporary traffic management), known difficult locations such as steep kerbs, wide road crossings with reduced visibility, or road crossings at free left-turn slip lanes are avoided. Furthermore, people with disabilities report that *every* journey involves constant anxiety about whether they will complete the journey safely. More than half of people with disability have more than one impairment (Statistics NZ, 2013) and many start from a baseline of low energy (Rimmer, Schiller, and Chen, 2012).

3.5 Trips not made: the crash data of perceived safety

Crash data presented above attests that New Zealand has a pedestrian safety problem. Crash numbers are not declining and there is no national approach to improve pedestrian safety with any measurable indicators of success. There are likely many systemic reasons why this is the case, including political motivations. At a local level, one reason why analysis of pedestrian safety is difficult is a lack of pedestrian volume data.

Counting pedestrians is useful for many reasons (Lindsey, Nordback, and Figliozzi, 2014), but volumes alone may misrepresent safety because people have different perceptions of risk that translate into different amounts of travel. Given that mobility aid use is correlated with disability and age (Burdett, 2014), and focus group findings confirm intuition that older people and those with disability find transport difficult (Mackett, 2015), counting people who use mobility aids is an objective proxy measure for perceived safety on a road crossing or footpath. The hypothesis for the use of mobility aid use as an indicator population is that the higher the relative proportion of mobility aid use, the more safe the location is perceived by local pedestrians. This hypothesis was tested with a brief series of pedestrian counts across four hours during a weekday and two hours on a weekend day at a roundabout in Thames, New Zealand. The results are shown below (Figure 1).

These results show that the most popular crossing point is the zebra crossing south of the roundabout. This crossing also had the highest proportion of people using mobility aids. Three of the splitter islands had no pedestrians using mobility aids across the six hours of counts. Counts at other locations have repeatedly shown that where accessibility is good, proportions of mobility-aided pedestrians are higher (Burdett, 2013).

Figure 1 Total number of pedestrians and proportion of mobility aid users at a roundabout crossing (Mary / Mackay Streets), Thames NZ, May 2014

4.0 DISCUSSION

4.1 Pedestrian safety outcomes in New Zealand

The first two research questions were:

1) How are reported pedestrian fatal and serious crash numbers and hospitalisations changing over time in New Zealand?; and
2) What reported causal factors feature in Traffic Crash Reports related to fatal and serious crash outcomes for pedestrians?

Reported crash data suggest that New Zealand has a pedestrian safety problem. Not only is there no significant decline apparent in fatal and serious pedestrian crashes over the last ten years, the crash locations and causal factors give little direction to Road Controlling Authorities tasked with providing safe environments for walking.

The most common causes of pedestrian fatal and serious injury according to traffic crash reports was ‘crossing’ and ‘heedless of traffic’. Ways to address these are to improve behaviour of pedestrians, and to improve awareness of motor vehicle drivers of the likely presence of people on the road (ie, road safety education); to lower the speed environment so that collisions are less likely and outcomes less severe; or to change the infrastructure so that crossing is inherently safer, or more firmly discouraged (ie, engineering interventions).

Improving road safety by improving human behaviour through education is difficult. In the long term, culture and legislative changes can result in improvements in embedded attitudes and behaviours, manifested for example in different give way behaviour between motorists and pedestrians crossing at side roads. However, there is no evidence that road safety education is effective in changing behaviour of individuals in the short-term.

Trends detailed in this paper suggest that the fatal and serious crash rate for older people may be increasing, because older people are walking less, but there is no reduction in fatal and serious casualties for pedestrians in this age group. Fatal and serious pedestrian casualties for people aged over 64 years are not declining.

Furthermore, walking is an important and health-supporting mode of recreation for all people, but for people aged over 65 years it is also a means to participation in social and recreational pursuits, which are themselves determinants of good health because they combat social isolation and loneliness (Steptoe, Shankar, Demakakos, & Wardle, 2013). Given that New Zealand has a rapidly ageing population (Super Seniors, 2016), it is increasingly important that environments for safe and accessible walking continue to be developed.

Older people also stay much longer in hospital when they are involved in a collision as a pedestrian. Therefore, the health cost of a pedestrian crash is much higher for older people. Older people are also more likely to identify with disability, and have increasing incidence of vision and mobility impairment, which means that environments promoting safety and accessibility are particularly important for this group. The count data from Thames and elsewhere suggests that the most attractive crossings for people using mobility aids are also attractive for all pedestrians, a point noted in the NZ Transport Agency's Pedestrian Planning and Design Guide: "By meeting the needs of the less able, a quality walking environment is provided for all." (NZ Transport Agency (2009), Section 3).

The case studies of crashes in Hamilton highlight complexities associated with responding to pedestrian safety issues. While any fatal crash outcome is tragic, with limited resources it is important to target investment where it is most likely to result in an improvement in some objective. Midblock pedestrian signals are probably perceived as very safe and accessible, however like zebra crossings, they can and do result in relatively high speed collisions if drivers fail to respond to the red signal. A more effective treatment is raised speed tables within the context of safe urban speed environment at or below 30km/h, because they increase pedestrian visibility; reduce collision rates; and have limited negative effects on access for motor vehicles (ITE, 2017).

Because traffic signals do not physically separate pedestrians from high speed traffic, beyond removing heavy vehicles and unnecessary traffic from mixed use streets, speed management is the most desirable outcome for any road crossing where pedestrians are expected to interact with motor vehicle traffic (NZ Transport Agency, 2009). Speed management can include physical traffic calming although the gold standard is provision of genuinely self-explaining roads resulting in operating speeds at or below 30km/h in urban environments (Charlton et al., 2010).

4.2 Counting presence and absence of the most vulnerable pedestrians: insights from focus group and pilot surveys

The third and fourth research questions were:

3) Who are the most vulnerable pedestrians, and how do they choose whether and where to travel?

4) How can pedestrian volume data inform investment in pedestrian safety?

The focus group confirms intuitive and anecdotal reports that people with disability (and by implication, a high proportion of older people) find travel as pedestrians particularly difficult, stressful and tiring. People with a disability make fewer trips (Shumway-Cook et al., 2005), and those in the focus group reported that they explicitly plan their routes as pedestrians to minimise energy expenditure while maximising perceived comfort, safety and personal security.

For these reasons, counting the presence of people with disability and older people can be a useful indicator of perceived safety. Higher proportions of people with mobility aids are observed at locations that are perceived to be more accessible (that is, barrier-free) and more safe.

5.0 CONCLUSIONS

New Zealand has a problem associated with the safety of pedestrians, and health costs per person are particularly high for older pedestrians who require safe and accessible infrastructure. Most fatal and serious crashes are in urban environments and involve pedestrians crossing roads. There are national and local implications that follow from these conclusions.

5.1 Recommendation: Increase the prominence of pedestrian safety in national road safety policy

It is also recommended that the next iteration of the national road safety strategy include more explicit policy and actions to improve safety for pedestrians. The numbers of pedestrian casualties are not falling, which is affecting the overall aims of the Safer Journeys strategy to reduce death serious injury on New Zealand's road network.

5.2 Recommendation: Count people crossing roads on foot, including indicator populations, to identify locations perceived as risky

It is recommended that City and District Councils use different tools to proactively prioritise investment in safe road crossings. The main recommended tool is to count people, to provide a denominator in the calculation of risk per pedestrian.

The most obvious way to find out which road crossing locations (both formal and informal) are perceived as most hazardous is to count who is there, using indicator populations to find out who is not there. This is most useful in medium-density locations (for example at roundabouts and refuge islands) because at higher density locations signalised crossings are more likely to be provided. Although signals are not necessarily the safest choice (for example, where there is potential for high motor vehicle speeds), they are probably perceived as the most accessible crossing.

An example of an observable indicator population is people using mobility aids such as a walking stick or wheelchair. At first glance it may seem that counting such a small proportion of a total is of little use. However, crashes themselves are a very small proportion of trips made. The significance of difference between small numbers is demonstrated in the sophistication of the KiwiRAP models of risk, which rely on relatively small numbers, which nonetheless enable prioritisation when the data are collected across an entire network (KiwiRAP, 2016). Comparing the proportion of mobility aid users in different locations around a town has been shown to quickly identify relatively inaccessible paths and crossings. Mobility aid use has a strong positive correlation with age, so catchment age distribution can be used to estimate the expected proportion of mobility aid users at a specific location (see Burdett (2014) for explanation of this method).

If Road Controlling Authorities work together to gather pedestrian volume data across a range of intersection and midblock crossing types, these data can be aggregated to better inform risk calculations. Technology such as video-recognition and combining manual surveys with automatic detection may help to bring survey costs down. RCAs can then use the aggregated data, combined with their own assessment of need in communities for safe, accessible road crossings, ultimately for the benefit of all New Zealanders.

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