Towards Zero Pedestrian Trauma: Literature Review and Serious Casualty Analysis

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Abstract

Pedestrian crashes alone constitute a substantial proportion of all road deaths world-wide. In Victoria, the number of pedestrian fatalities increased from 41 in 2007 to 59 in 2008. Given the increasing trend of pedestrian fatalities it is an opportune time to review current approaches and develop a new suite of innovative ways to take the next major step forward to eliminating serious pedestrian trauma. A key initial aim of the present study was to understand the contributing behavioural and environmental factors and their role in pedestrian crash and injury risk in Victoria from 2004 to 2008. This paper presents two major components of a larger study and includes, i) a review of the Australian and international literature spanning the past five years in combination, and ii) detailed analyses of pedestrian crashes in Victoria.

Key Words: Pedestrian, Victoria, Crash analysis, Review

Introduction

Walking is a major mode of transport, is a component of most trips, and has obvious benefits for the health and well-being of individuals, the community and the environment. Pedestrian safety concerns in Victoria (and Australia) are, however, likely to grow if initiatives that promote walking and public transport use are successful in increasing the amount of walking without concurrent improvements in road safety initiatives. Crashes involving vulnerable road users represent a major road safety problem world-wide and there is growing awareness within the road safety community that vulnerable road users may have their own particular needs and difficulties in using the road transport system.

Following the introduction of two major speed initiatives in Victoria in 1990 and 2003, two large step-reductions occurred, respectively. The first reduction involved the introduction of automated speed cameras and a boost in random breath testing in 1989. The second involved a reduction in the tolerance level of compliance with speed limits along with a range of improvements in speed enforcement, all of which were introduced in 2002. These reductions are illustrated in Figure 1.

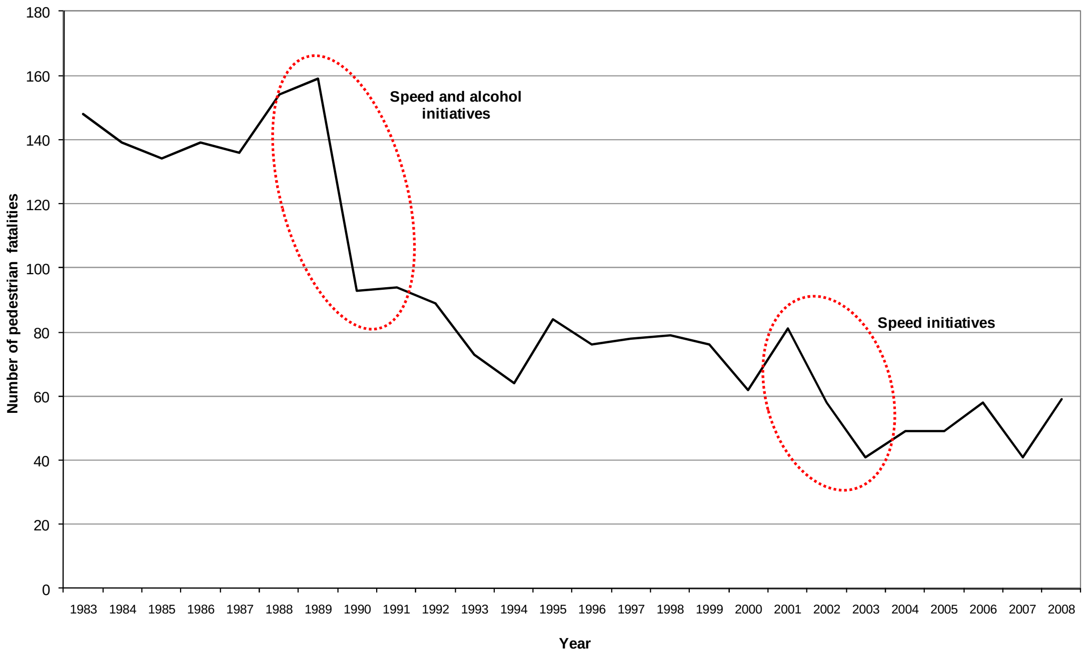

Figure 1: Number of pedestrian fatalities from 1983 to 2008

Since 2003, however, the general trend for pedestrian deaths appears to be on the incline. In particular pedestrian deaths have increased markedly from a total of 41 pedestrian fatalities in 2007 [2] to 59 in 2008. Therefore, it is an opportune time to review current approaches to managing pedestrian safety to formulate a new suite of innovative ways to take the next major step forward to eliminating serious pedestrian trauma.

To achieve this aim, the following objectives were set: i) to define the current problem by better understanding the nature and characteristics of serious pedestrian casualties to facilitate a fuller understanding of crash circumstances and injury outcomes for high priority pedestrian crash types, and ii) to use this information in conjunction with the Safe System approach to guide the development of a set of pedestrian crash countermeasures to effectively address the high priority areas of pedestrian trauma in Victoria. Serious pedestrian casualties are defined as those pedestrians killed or hospitalised as a result of involvement in a road crash.

Methods

The first study objective comprised two phases, i) a review of the Australian and international literature spanning the past five years, and ii) a detailed analysis of pedestrian crashes in Victoria using crash data and geographic information system mapping.

The first phase involved a comprehensive examination of the literature published during the last four to five years in recognition that some major reviews of pedestrian safety were conducted. This review identified factors that have contributed to crash and injury risk and provided a good understanding of the current state of knowledge of countermeasure effectiveness. The review of the literature is presented having regard to delivery of Safe System outcomes and identification of pedestrian safety best practice. Furthermore, input has been sought from those agencies and practitioners pursuing best practice.

The second phase comprised two components, i) descriptive analyses of serious pedestrian casualty crash characteristics for the period January 2004 to December 2008, and ii) spatial analyses of serious casualties over the same period. Only the first of these two components has been completed to date. For the first component, several variables were identified for analysis including injury severity, road geometry, DCA, day of week, speed zone, road class, time of day, traffic control type, and local government area (LGA). Analyses comprised frequencies and cross-tabulations of these descriptor variables and are presented in either graphical or tabular format.

Literature review

Risk factors for pedestrian crashes

A comprehensive review of the literature over the past five years (2004 - 2009) revealed that the most vulnerable subgroups of pedestrians continue to be: children, the elderly and the intoxicated. More specifically the groups include; young children aged less than ten years [3, 4], older adults aged greater than 70 years [1] and young adults aged between 15 and 24 years who were under the influence of alcohol [5, 6]. The contributory risk factors vary between these three high risk pedestrian groups. Elderly pedestrians are susceptible to physical, perceptual and cognitive changes that occur through the natural ageing process that can compromise their ability to safely cross the road. In contrast, young children are still developing the skills and strategies needed to cross the road safely, including risk perception, visual attention, action and perception. Research shows that the abilities necessary to interact safely in traffic improve markedly after 7 years old, but for many these abilities may not be fully developed until at least 11 to 12 years of age [7]. Emerging areas of research include pedestrian distractions from head phones or mobile phones [8], as well as pedestrian attitudes and perceived risk of disobeying road rules [9]. Although intoxicated pedestrians constitute a large proportion of pedestrian injuries and fatalities the debate continues as to what constitutes a problematic blood alcohol concentration.

Countermeasures

Meeting the mobility and safety needs of pedestrians of all ages will require a comprehensive future strategy within the broad philosophy of the Safe System approach. The Safe System approach requires all aspects of the transport system (i.e., roads, vehicle speeds, vehicles, pedestrians and the users of the system) to work together for the safest possible outcomes. Within this system, behaviour and education programs can target the users of the system, while road design and infrastructure impact upon the users, the roads and vehicle speeds.

Educational, awareness and behaviour change programs are vital to the success of improving pedestrian safe mobility, particularly to increase the adoption of safe walking practices. It appears that programs that include both educational and engineering components can work well for child and elderly pedestrians [10,11]. Unfortunately very few programs have been developed for the purposes of educating adults about alcohol impairment and its effect on pedestrian safety therefore greater enforcement of responsible service of alcohol may be required [12]. While education, training, publicity and promotion programs are valuable tools, these strategies often require a long period of time until the benefits can be realised.

Geometric countermeasures that can modify the physical environment of the transport system can provide quick and effective mobility and safety benefits. A continued effort to introduce measures that comprise a 'Woonerf' design such as pavement narrowing, installation of refuge islands, alterations to the road surface, installation of roundabouts, installation of paths next to roads and raised medians are beneficial to pedestrians. Even small reductions in vehicle travel speed (5-10km/h) can produce substantial reductions in the risk to pedestrians [13]. Traffic calming methods consisting of physical measures aim to reduce negative driver behaviour such as excessive speed. For example, dense speed humps and high speed humps have been shown to be effective in reducing speeds as a single countermeasure [14].

Perceptual countermeasures are also likely to influence travel speed by altering how drivers perceive the road and/or roadside. Treatments such as transverse lines, lane-edge herringbone treatments, median treatments, and enhanced post spacing have been shown to successfully reduce travel speeds in certain road environments [15, 16]. For example, there is evidence to suggest that perceptual countermeasures are more effective at intersections compared with straight stretches of road [17]. Considering that a high proportion of pedestrian serious injuries and deaths occur following a collision with a vehicle, the separation of these travel modes has been successful in reducing these conflicts. Vehicle and pedestrian separation measures include footpaths, barrier fencing and guardrails and over and underpasses. In addition, there are some ITS technologies that can enhance speed compliance, including in-vehicle speed alerting and speed limiting devices, out-of-vehicle variable message signs and an active hood lift system whereby the hood is lifted during a crash event, preventing a pedestrian hitting the hard structures of the engine [18, 19]. Although in-vehicle systems are still under development and assessment, preliminary estimates are promising regarding their effectiveness in reducing travel speeds and mitigating injury levels in the event of a crash. A more comprehensive list of available countermeasures is provided in the Towards Zero Pedestrian Trauma literature review (in press) [20].

Results

Crash analysis

Analysis of the crash data showed that there were 3,717 serious pedestrian casualties in Victoria from 2004 to 2008. Figure 2 presents the distribution of these serious casualties during this time period. To put these figures into context, the number of pedestrians killed and seriously injured is presented as a percentage of the total number of pedestrians involved in a casualty crash each year. There is no discernable trend with regard to fatalities as they appear to fluctuate particularly from 2005 onwards.

Analysis of trends over the study period is not possible for seriously injured pedestrians due to a system change in the collection of Victorian accident data in late 2005. This change produced a discontinuity which does not allow for the comparison of trends of non-fatal data in the period prior to December 2005 to the period post December 2005. Therefore, only the years 2004 and 2005 are comparable as are the years 2006 to 2008. It is still valid, however, to use post-2005 data to look at the aggregate 5-year values for problem identification and analysis which is the approach used in the charts shown (except Figure 1) [21].

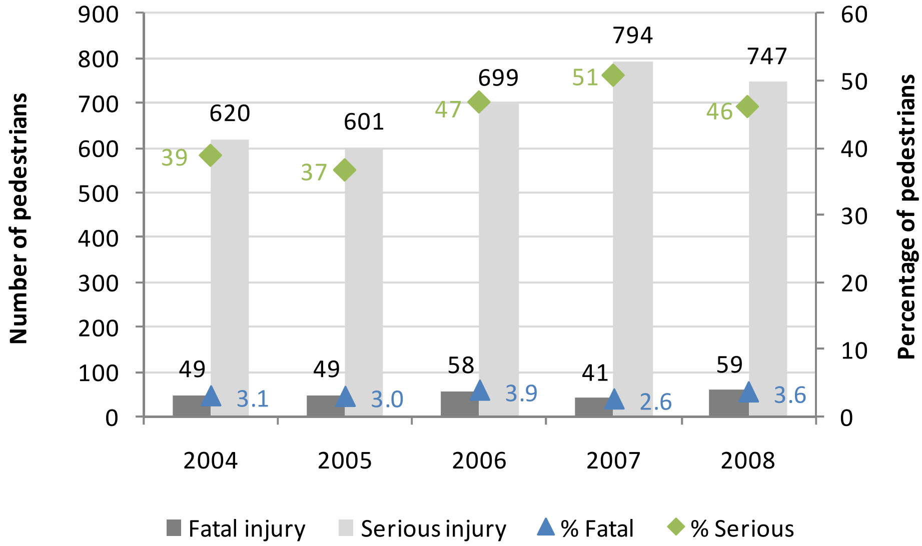

Figure 2: Number of pedestrians killed or seriously injured, 2004-2008

The percentage distribution of pedestrian serious casualties by age group and gender is shown in Figure 3. Age groups contributing most to the number of serious pedestrian casualties were the 18 to 24 years (16%), 25 to 34 years (17%) and 65 years and over (20%) age groups, which are equal to over 50 per cent of the total number of pedestrians killed or seriously injured from 2004 to 2008. In terms of gender, males were over-represented in all age groups except the 65 years and over age group. Population statistics [16] show that the male to female ratio is virtually equal for each age group except the 65 years and over age group where there is a slightly higher proportion (1.5%) of women.

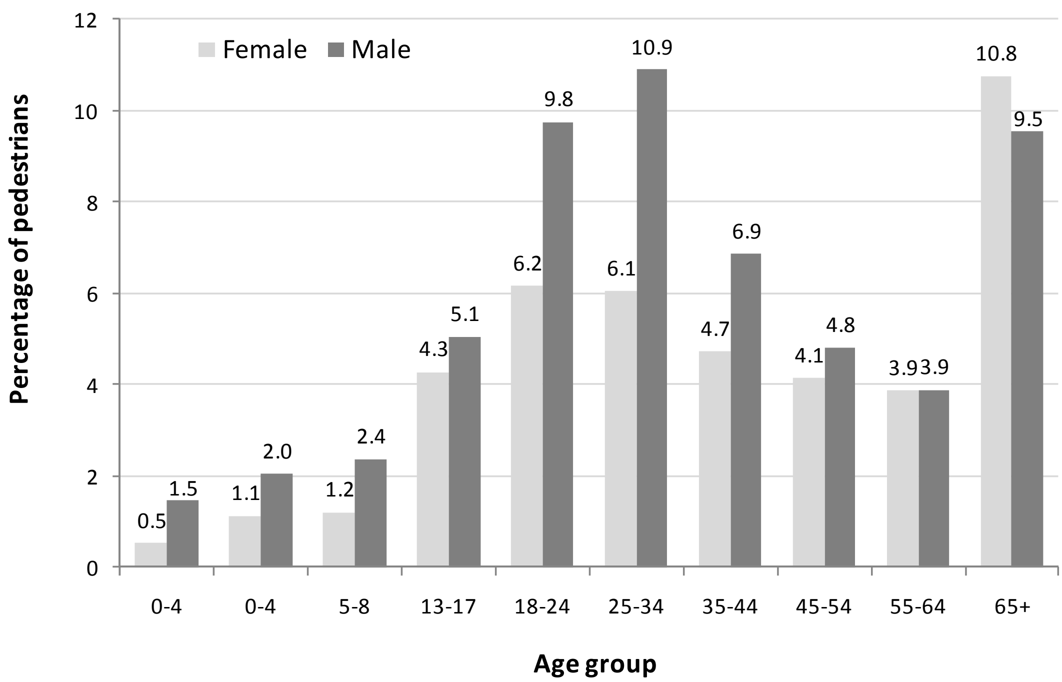

Figure 3: Percentage distribution of serious pedestrian casualties by age group and gender; 2004-2008 combined

Results of analysis of serious pedestrian casualties by road geometry are shown in Figure 4. Fifty-four percent of pedestrians were killed or seriously injured at mid-blocks and 45 percent at intersections. The distribution of casualties across intersections is predominately spread across cross and T-intersections (23% and 21%, respectively) while one per cent is distributed across multiple and Y-intersections.

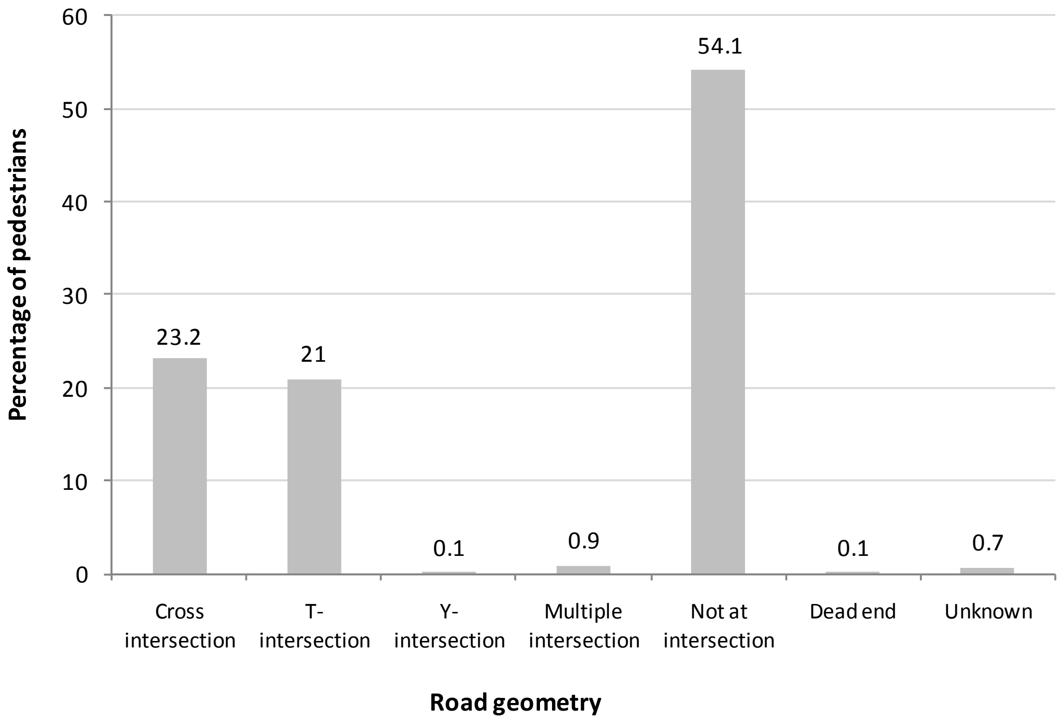

Figure 4: Percentage distribution of serious pedestrian casualties by road geometry

To determine whether a particular age group was more frequently represented at a particular type of road geometry, a cross tabulation between all road geometry types and age group was performed. Results for the two main intersection types only are depicted in Figure 5, which show that pedestrians up to the age of 18 years are more likely to be killed or seriously injured at T-intersections while the converse is true for those aged 18 years and over.

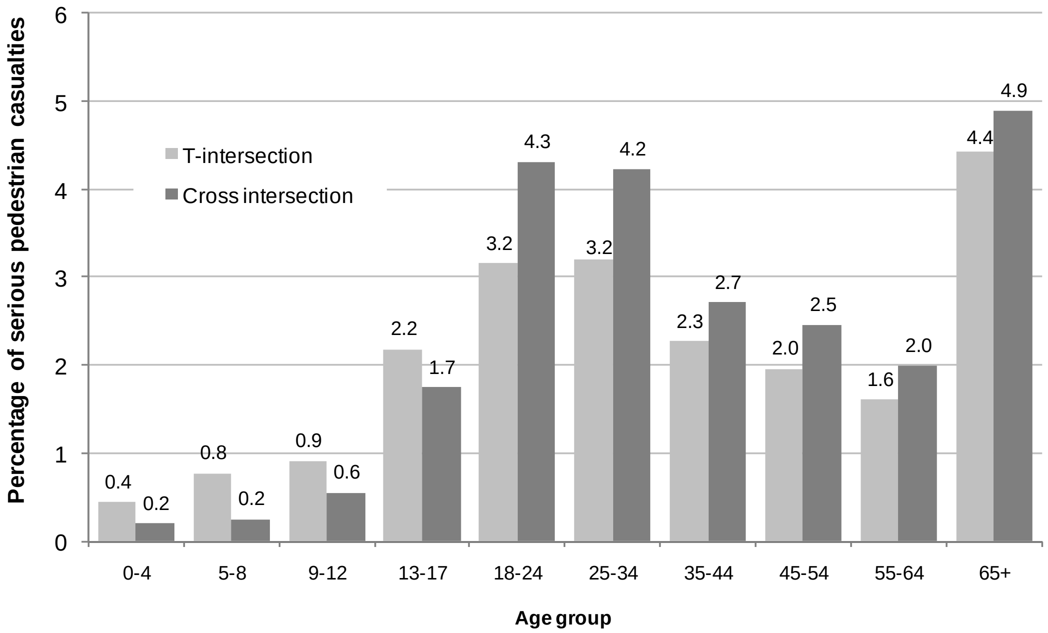

Figure 5: Percentage distribution of serious pedestrian casualties by road geometry

Figure 6 depicts the percentage distribution of serious pedestrian casualties by Definitions for Classifying Accidents (DCA). It shows that near and far side crash types are most problematic for pedestrians implying a gap selection problem. These two DCAs were also the most common at both intersections and mid-blocks. When analysed by age group, the near side crash type is most common to all age groups except amongst 5 to 8 year olds.

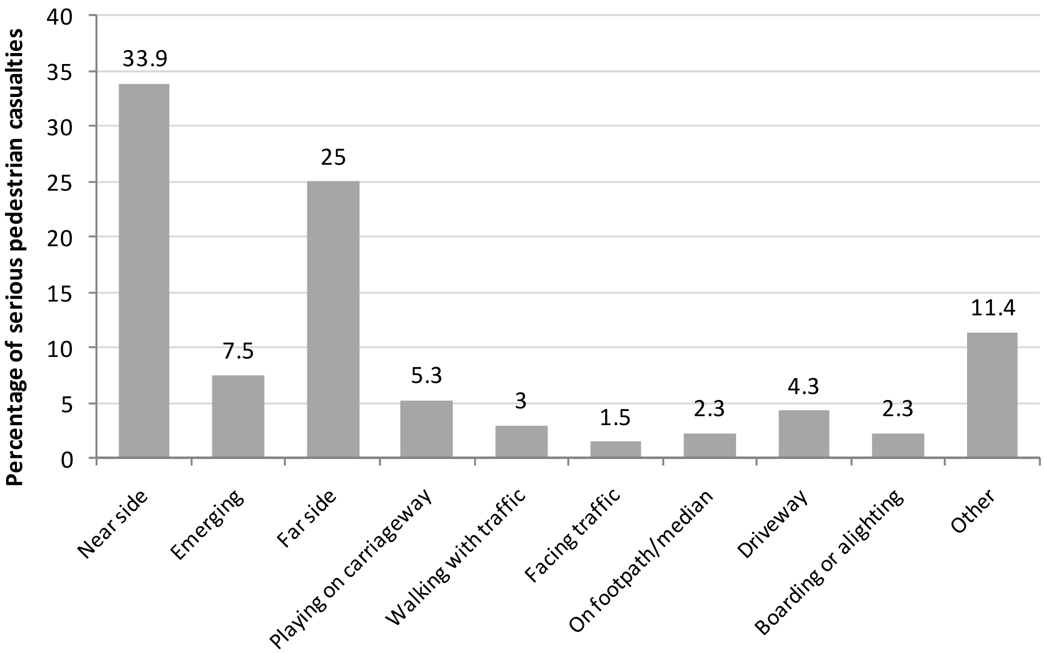

Figure 6: Percentage distribution of serious pedestrian casualties by DCA

Figure 7 depicts the percentage distribution of serious pedestrian casualties by day of week. Although the percentage differences between each day of the week are small, the general trend appears to be one of increasing numbers of serious casualties as the end of the week approaches.

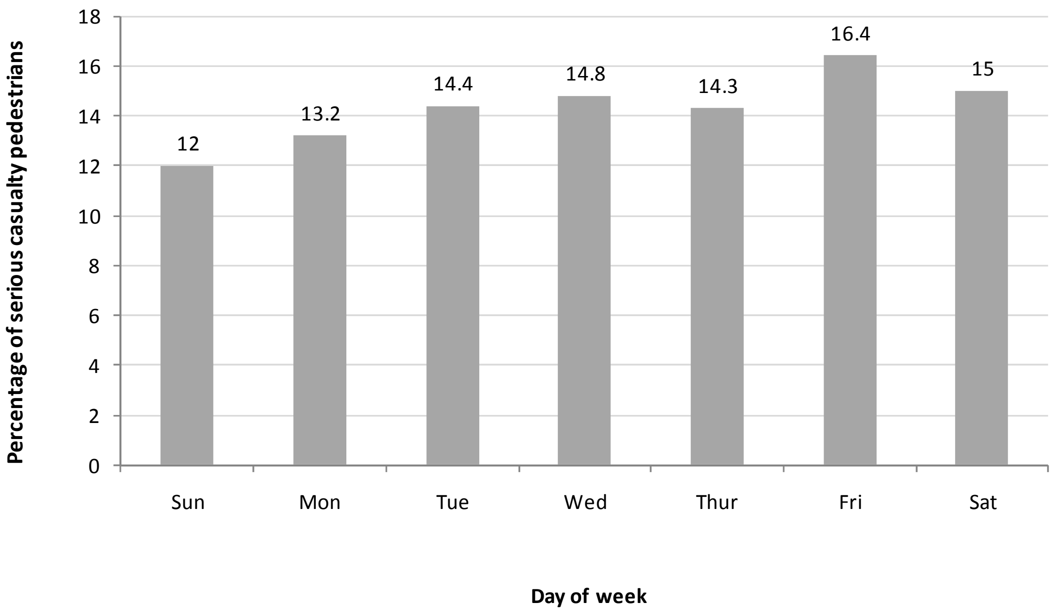

Figure 7: Percentage distribution of serious pedestrian casualties by day of week

An analysis of serious pedestrian casualties by speed zone showed that 42 per cent and 32 per cent of serious casualties occurred in 60 km/h and 50 km/h speed zones, respectively, 7 per cent occurred in both 70 km/h and 80 km/h speed zones, 5 per cent occurred in 40 km/h speed zones and 3 per cent occurred in 100 km/h speed zones. The remaining 3 per cent either occurred off-road or the speed zone was not known. A breakdown of the percentage distribution of serious casualties in 50 km/h and 60 km/h speed zones by road type is shown in Table 1.

Speed zone	Local roads (%)	Main Roads (%)	Highways (%)
50 km/h	75	16	8
60 km/h	28	54	17

Table 1: Percentage distribution of serious pedestrian casualties by road type in 50 and 60 km/h speed zones

Analysis by time of day showed a greater percentage of pedestrians were seriously injured or killed in the afternoon to evening period spanning 3 pm to 7 pm, with the peak occurring between 3 and 4 pm. This is illustrated in Figure 8. Further analysis by age group showed that the peaks vary according to age group. An example is shown in Figure 9.

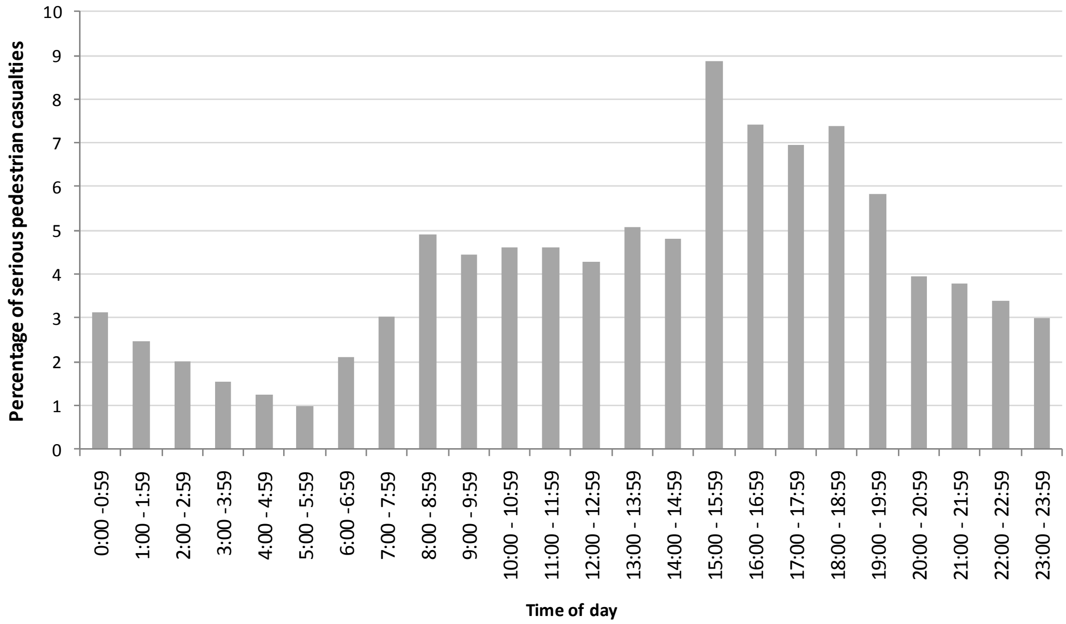

Figure 8: Percentage distribution of serious pedestrian casualties by time of day

Figure 9 shows that pedestrians aged 18 to 24 years of age were most likely to be killed or seriously injured between 11pm and 2am, while pedestrians aged 25 to 34 years were more likely to be killed or seriously injured from 6 to 7pm. The peak time for pedestrians aged 65 years and over covered a larger portion of the day (i.e, between 9 am to 7 pm) compared to other age groups, however they appeared to be most at risk between 9 am to 11 am and then from 2 pm to 3 pm.

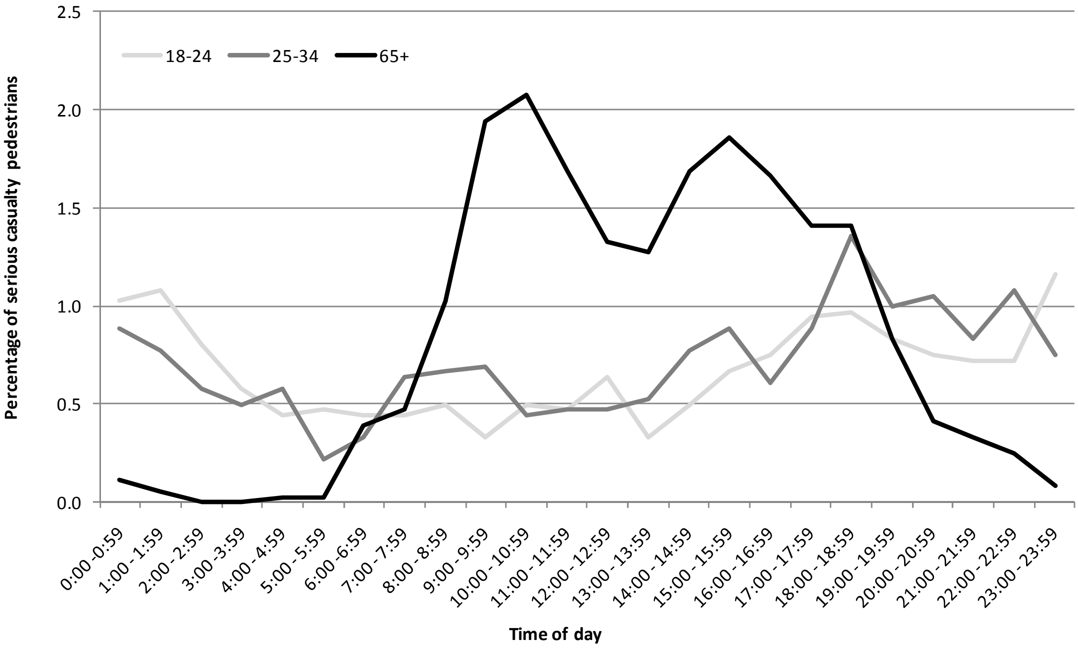

Figure 9: Frequency distribution of serious pedestrian casualties by time of day for most problematic age groups (all days of week)

Analysis of the traffic control type showed that the majority (67%) of serious pedestrian casualties were struck at intersections where no traffic control was reported. Twenty per cent of serious casualties were struck at locations with traffic lights (or stop-go-lights) and three percent were struck at pedestrian crossings. These results are illustrated in Figure 10. For those cases in which no traffic control was reported, further examination by speed zone revealed that 35 per cent of serious pedestrian casualties occurred on 50 km/h roads and 38 percent on 60 km/h roads. Further investigation is currently being undertaken by VicRoads into the high proportion of Police-reported casualty crashes in which no traffic control is reported. Investigations at MUARC have shown that a very high percentage of these are actually controlled by either a 'stop' or 'give way' sign.

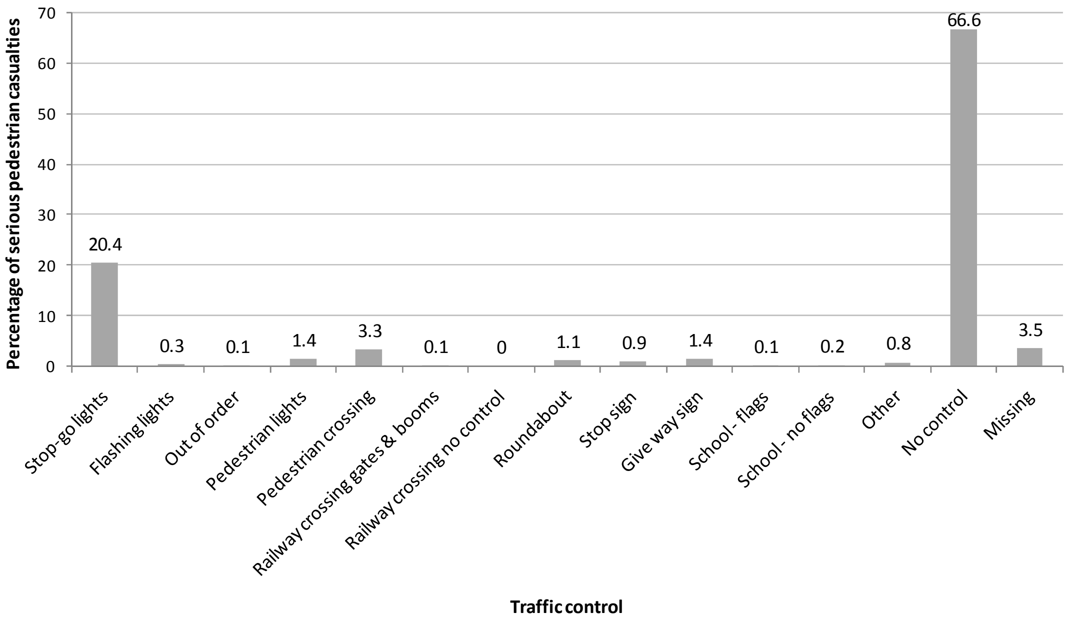

Figure 10: Percentage distribution of serious pedestrian casualties by traffic control type

Table 2 presents the 10 Local Government Areas (LGAs) which have the highest number of Police-reported serious pedestrian casualties during 2004 to 2008 in descending order. The City of Melbourne experienced the greatest proportion of these, reflecting the very high level of pedestrian activity coupled with high traffic volumes in and around the central business district.

LGA	Frequency	Percentage	Population (2008)[1]	Serious pedestrian casualties per annum per 100,000 pop.
Melbourne	415	11.2	89525	92.7
Port Phillip	180	4.8	93985	38.3
Dandenong	161	4.3	135578	23.8
Moreland	147	4.0	146261	20.1
Boroondara	141	3.8	165802	17.0
Darebin	137	3.7	137700	19.9
Geelong	134	3.6	212367	12.6
Brimbank	132	3.6	181564	14.5
Yarra	123	3.3	76591	32.1
Monash	120	3.2	173168	13.9

Table 2: List of Local Government Areas with the most serious pedestrian casualties recorded, 2004-8

Conclusions

Despite an overall two-thirds reduction in pedestrian fatalities in Victoria over the last twenty years, around 800 serious casualties continue to occur each year. Of these, one-third comprise 18-34 year-olds and 20 percent those aged 65 years old and over. Over 50 percent of serious pedestrian casualties occur away from an intersection. By day-of-week, 15 percent more pedestrians are killed or seriously injured on a Friday than would be expected if each day of the week was equally represented. Vehicle travel speed is well understood for its role in pedestrian injury severity and is likely to have had a significant involvement in the 74 percent of serious casualties occurring in 50 and 60 km/h speed zones. However, actual vehicle travel speeds and pedestrian exposure data would need to be analysed to confirm this.

In anticipation of a more comprehensive mapping exercise, pedestrian S.C.s by Local Government Area were analysed and showed that the top ten LGAs in Victoria sustained 45% of the total pedestrian serious casualties in the State over the period 2004-2008. The City of Melbourne alone experienced 83 S.C.s per year on average, representing 93 S.C.s per annum per 100,000 population – six times the average rate than for the whole of Victoria.

Geospatial mapping of crashes is the next stage of the analysis and will take place once the dataset becomes available. This will enable the more precise identification of the characteristics of pedestrian serious casualties in Victoria, including the identification of clusters in particular regions and the types of locations and roads where pedestrian crashes are occurring. Following this phase will be to devise new and innovative countermeasures targeted at the localities and land use characteristics most heavily represented by pedestrian serious injuries and fatalities will be devised.

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[1] ABS 3218.0 – Regional Population Growth Australia, 2008-09.

Acknowledgements

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