Hazard
(Edition No. 71)
Winter 2010
Victorian Injury Surveillance
Unit (VISU)

www.monash.edu.au/muarc/visu

Monash University
Accident Research Centre

Traffic-related pedestrian injury in Victoria (1): hospital-treated injury

Authors: Erin Cassell, Angela Clapperton, Hafez Alavi[1], Sarah Jones[2]

This is the first of two issues of Hazard on traffic-related pedestrian injury. This issue is focused on hospital-treated pedestrian injury. Traffic-related pedestrian deaths recorded on the coroners' database will be reported in the next issue of Hazard which will be released later in the year.

Summary

Trend in traffic-related hospital-treated pedestrian injury: 1999-2008

- Over the decade 1999-2008 there was a significant 18% decline in the number of traffic-related pedestrian hospital admissions in Victoria and a significant 29% decline in pedestrian admission rates. The number of traffic-related pedestrian ED presentations also fell by 21% over the decade.

Frequency and pattern of traffic-related hospital-treated pedestrian injury: 2006-08

- Over the 3-year period 2006-08, there were 3,483 hospital-treated pedestrian traffic-related injury cases in Victoria (2,150 hospital admissions and 1,333 ED presentations), an average of 1,161 cases per year (717 hospital admissions and 444 ED presentations).

Gender

- Males were over-represented in pedestrian injury cases, accounting for 59% of hospital admissions and 54% of ED presentations.

Age

- Thirty-four percent of injured pedestrians (n=1,172) were aged between 15 and 29 years. However, admission rates were highest among pedestrians aged 80-84 years and those aged 85 years and older (both 31 per 100,000), followed by those aged 75-79 years (25/100,000) and those aged 15-19 years (22/100,000). ED presentation rates were highest among pedestrians aged 15-19 years (18/100,000), followed by those aged 20-24 years (17/100,000) and 25-29 years (12/100,000).

Language spoken in country of birth

- Overall and for males and females separately, pedestrians born in mainly non-English speaking countries had the highest hospital admission and ED presentation rates, followed by Australian-born pedestrians and pedestrians born in other mainly English speaking countries.

Driving convention in country of birth

- Overall and for males and females separately, pedestrians born in countries where the convention is for vehicles to drive on the right side of the road had higher hospital admission and ED presentation rates than Australian-born pedestrians and pedestrians born in

1 Hafez Alavi is a PhD candidate at MUARC. Hafez thesis is in the area of pedestrian safety. He wrote the first draft of this *Hazard*.
2 Dr Sarah Jones is Specialty Registrar (Public Health), Department of Primary Care and Public Health, Cardiff University. Sarah contributed to the first draft of this issue when a visiting scholar at MUARC.







countries where, as in Australia, the convention is to drive on the left side of the road.

Local Government Area (LGA) of residence (hospital admissions only)

- Pedestrian hospital admission rates were compared by LGA. The average (mean) pedestrian admission rate over the period 2006-8 for all Victorians was 13.7/100,000 population. The LGAs that had much higher pedestrian admission rates (cut-off 20/100,000) were: Melbourne (30.5); Yarra (29.8); Port Phillip (29.3); Maribyrnong (26.9); Stonnington (26.6); Moreland (25.7); Darebin (22.8); and Greater Dandenong (21.0).

Alcohol involvement (hospital admissions only)

- Alcohol involvement in pedestrian hospital admissions was identified if cases contained either an alcohol-related diagnosis or external cause code. Alcohol involvement in injury is underestimated on the hospital admissions dataset. Analysis showed that at least 12% of all pedestrian hospital admissions involved alcohol (n=264) and 81% of these alcohol-related admissions were male. Pedestrians aged 15-29 years accounted for 44% of alcohol-related cases, followed by those aged 30-44 (32%) and those aged 45-59 (17%).
- Seventy-four percent of alcohol-related admitted pedestrians were Australian-born, 6% were born in English-speaking countries and 10% were born in non-English speaking countries, although admitted pedestrians born in non-English speaking countries had the lowest rate of alcohol involvement.
- Although 89% of alcohol-related pedestrian admissions were caused by collisions with cars, the proportion of admissions that were alcohol-related was higher among pedestrians injured in collisions with trams (31%) and trains (23%) than with cars (13%).

Seasonal variation

- A higher proportion of hospital-treated pedestrian injury occurred in winter (27% of admissions and 28% of ED presentations) and autumn (27% of admissions and 27% of ED presentations) than in spring (25% of admissions and 24% of ED presentations) and summer (21% of admissions and 22% of ED presentations).

Type of vehicle involved

- Around 90% of pedestrians were injured in collisions with cars, pickup trucks and vans and around 3% by heavy transport vehicles (trucks) or buses. The remaining cases were injured in collisions with motorcycles, bicycles, trains, trams and a few in collisions with pedestrian conveyances such as mobility scooters, wheelchairs and skateboards.

Injury type and site

- Among hospital admissions, the major injury types were fractures (46%) and intracranial injuries (14%), whereas among ED presentations the major types of injury were superficial injuries (26%) and dislocations, sprains or strains (23%).
- Among hospital admissions, the head, face and neck (35%) and lower extremity (35%) were the most commonly injured body regions, whereas among ED presentations lower extremity injuries were most frequent (41%), followed by injuries to multiple body regions (21%).

Injury severity (hospital admissions only)

- The average (mean) length of stay of hospital admissions was 4.9 days (5.0 days for males and 4.8 for females). In general, the average length of stay increased with increasing age.
- The severity of injury among hospitalised cases was measured using the International Classification of Disease (ICD)-based Injury Severity Score (ICISS) which is a 'threat to life' scale. Overall, 40% of pedestrian admissions were classed as 'serious' (41% of male cases and 39% of female cases). This is a much higher rate of 'serious' cases than found among hospitalisations for all other unintentional injury causes combined (15%). Injury severity appeared related to the mass of the vehicle involved in the pedestrian collision, with the exception of motorcycles.

Hospital costs (admissions only)

- The total hospital costs of pedestrian injury admissions over the three years 2006-2008 was $18.3m. (an average of $6.1m. per year). The average (mean) cost per pedestrian admission was $8,525 (range: $698 to $85,219) compared with an average cost of $4,721 for all causes of unintentional injury combined. The only broad cause of injury grouping that had a higher average cost per admission than traffic-related pedestrian injury was choking and suffocation ($10,291 per admission).

Over the decade 1999-2008 traffic-related hospital-treated pedestrian injury rates decreased significantly, perhaps when there may have been some increase in walking as a form of transport in inner urban areas which are among the highest risk locations for pedestrian injury. Available evidence indicates that the downturn in injury was largely due to the reduction of the default vehicle speed limit to 50km/hr in 2001 (with the effect observed between 2002 and 2005) along with strengthened enforcement of traffic speed limits, but other interventions may have played a small part.

In the last three years of the decade progress on reducing pedestrian injury has stalled, which suggests that it is time to re-invigorate commitment to preventive action. Study results indicate that some priority should be given to research and interventions that aim to reduce injury in males aged 15-29, older people, intoxicated pedestrians, people born in mainly non-English speaking countries especially those that have the convention of driving on the right, children (because of their special vulnerability) and the LGAs with comparatively high pedestrian admission rates.







Introduction

Almost all road users are pedestrians for some or all of any journey and walking is the most sustainable mode of transport available. Walking contributes to both population environmental health and individual health, so is identified as a 'green' active transport mode. Communities that foster walking benefit from reduced traffic congestion and higher quality of life. The economic benefits of walking include reduced health care costs, facilitation of essential motorised travel and increased economic vitality. 'Walkable' communities are also more democratic and equitable as they better meet the mobility needs of all community members: be they young, old, rich or poor (Walkinginfo, 2009).

Our cities, however, are rarely designed for pedestrians and walking. Although much effort has been put into modifying transport systems and improving city planning, there remains many physical, organisational and safety barriers that deter people from comfortably choosing to walk. Lack of safety impacts the walkability of the environment in two ways. First, pedestrian crashes deter people from walking, and parents from allowing children to walk, because of the actual and perceived risks in the physical environment. Second, pedestrian crashes result in large individual and societal costs (Connelly & Supangan, 2006). These include: the direct cost of medical treatment and the long-term care; the legal and personal costs of the emotional and physical pain and reduced quality of life for the injured and their families; and the loss of productivity due to temporary or permanent work absenteeism.

In this edition of Hazard the frequency, pattern and trends in traffic-related pedestrian injury in Victoria are investigated with a view to identifying appropriate interventions to reduce the occurrence of pedestrian crashes and the severity of crash outcomes.

Method

Case selection

Traffic-related pedestrian injury cases for the study years were selected from two different datasets, the Victorian Admitted Episodes Dataset (VAED) and the Victorian Emergency Minimum Dataset (VEMD).

Hospital admissions were selected if the admission occurred between 1 Jan 1999 and 31 Dec 2008 for the trends section and 1 Jan 2006 and 31 Dec 2008 for the detailed analysis section.

Cases were selected if the first external cause code was in the range V00-V09 'Pedestrian injured in transport accident' and the code had a fourth character indicating the accident was 'traffic' related. (A traffic accident is any vehicle accident that occurs on the public highway). Further selection criteria are listed in Box 1.

Hospital ED presentations (non-admissions) were selected if the ED presentation occurred between 1 Jan 1999 and 31 Dec 2008 for the trends section and 1 Jan 2006 and 31 Dec 2008 for the detailed analysis section.

Cases were selected if the cause of injury was 'pedestrian' AND the intent was 'unintentional' AND the injury occurred on a 'road/street/highway'. All case narratives were then checked for relevance and any that were not considered traffic related were deleted (e.g. 'fell while walking on footpath', 'injured ankle when stepping in gutter' etc). Further selection criteria are listed in Box 1.

Rates and trends

Age-adjusted rates were calculated using the direct standardisation method with the Victorian population at June 30, 2001 as the standard. Trends were determined using a log-linear regression model of the rate data assuming a Poisson distribution of injuries. A trend was considered to be statistically significant if the p-value of the slope of the regression model was less than 0.05. (See Box 2)

Results

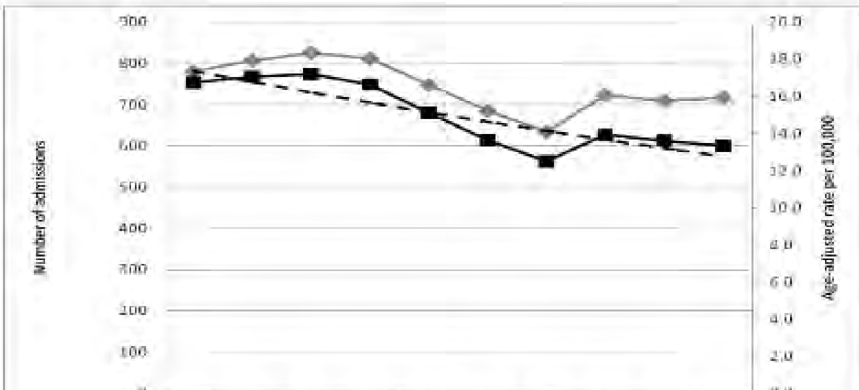
Trend in the frequency and rate of traffic-related pedestrian hospital admiss-ions and ED presentations (Victoria 1999-2008)

The trend in the frequency and rate of unintentional traffic-related pedestrian hospital admissions and ED presentations were plotted for the decade 1999-2008.

Hospital admissions

There were 7,443 hospital admissions for traffic-related pedestrian injury recorded on

Trend in the frequency and rate of unintentional traffic -related pedestrian injury hospital admissions, Victoria 1999-2008 **Figure 1**



	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
frequency	781	807	826	812	748	685	634	723	710	717
rate	16.7	17.0	17.2	16.7	15.1	13.7	12.5	13.9	13.6	13.4

Source: Victorian Admitted Episodes Dataset (VAED)







the Victorian Admitted Episodes Dataset (VAED) over the 10-year period 1999-2008, an average of 744 admissions per year (range 634 to 826). Figure 1 shows that the frequency and rate of pedestrian hospital admissions increased in the first three years of the decade, and then decreased steadily to 2005. There was a sharp increase in 2006 and a leveling off since then.

Trend analysis shows that over the 10-year period 1999 to 2008 there were significant reductions in both the frequency and rate of hospital admission for pedestrian injury:

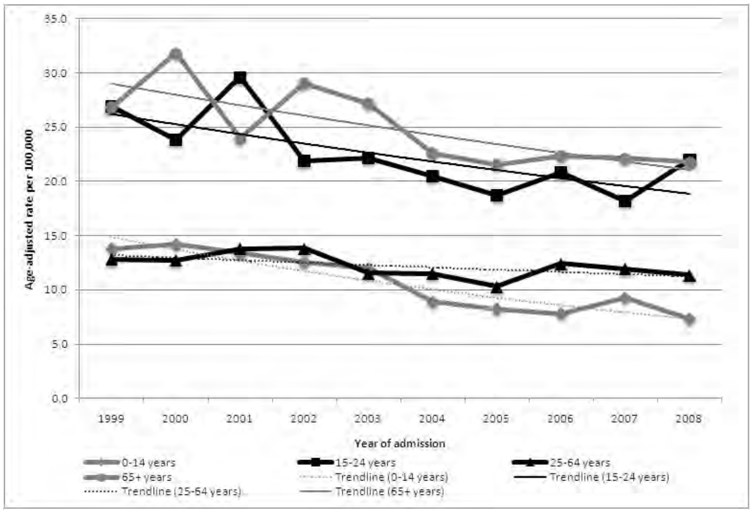
- The frequency of admissions decreased significantly from 781 in 1999 to 717 in 2008, representing an estimated annual decrease of 1.9% (95% confidence interval -3.5% to -0.3%) and an overall reduction of 18% (-30% to -3%)
- Admission rates decreased significantly from 16.7/100,000 in 1999 to 13.4/100,000 in 2008, representing an estimated annual decrease of 3.4% (95% confidence interval -5.0% to -1.8%) and an overall reduction of 29% (-40% to -17%). Figure 1

Over the decade, male hospital admission rates for pedestrian injury were consistently higher than those for females. Trend analysis indicated that there were similar and significant decreases in the rate of hospital admissions for male and female pedestrians (30% vs. 28%).

Figure 2 shows the trend in pedestrian injury hospital admission rates for four age groups: 0-14 years, 15-24 years, 25-64 years and 65 years and older for the 10-year period 1999 to 2008. People aged 65 years and older and those aged 15-24 consistently have higher rates of traffic-related pedestrian injury than those aged 0-14 years and 25-64 years. Trend analysis found that there have been significant reductions in the rate of pedestrian hospital admissions for all age groups, but particularly for children:

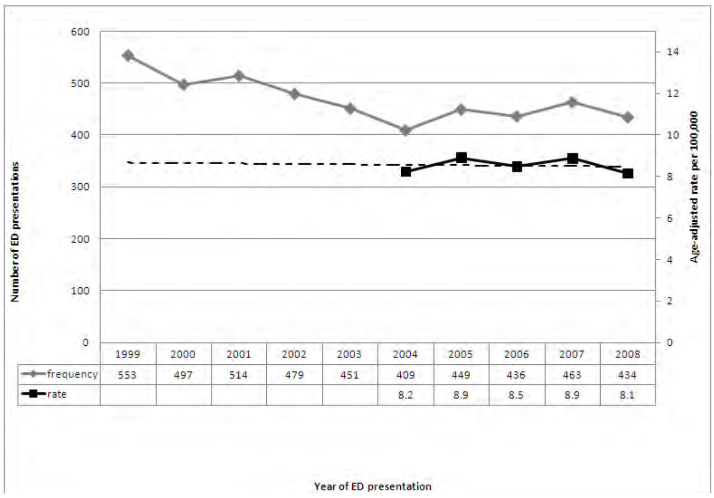
- Admission rates for child pedestrians aged 0-14 years decreased significantly from 13.8/100,000 in 1999 to 7.3/100,000 in 2008, representing an estimated annual decrease of 7.5% (95% confidence interval -10.4% to -5.2%) and an overall reduction of 54% (-67% to -41%)

Trend in unintentional traffic-related pedestrian injury hospital admission rates by age group, Victoria 1999-2008 — **Figure 2**



Source: Victorian Admitted Episodes Dataset (VAED)

Trend in the frequency and rate of ED presentations for unintentional traffic-related pedestrian injury, Victoria 1999-2008 — **Figure 3**



Source: Victorian Emergency Minimum Dataset (VEMD), rates only calculated for years in which all 38 hospitals offering a 24-hr ED service contributed to the VEMD (2004-2008)

- Admission rates for pedestrians aged 15-24 years decreased significantly from 26.9/100,000 in 1999 to 22.0/100,000 in 2008, representing an estimated annual decrease of 3.7% (95% confidence interval -6.6% to -0.9%) and an overall reduction of 31% (-50% to -9%)
- Admission rates for pedestrians aged 25-64 years decreased significantly from 12.8/100,000 in 1999 to 11.4/100,000 in 2008, representing an estimated annual decrease of 1.8% (95% confidence interval -3.8% to 0.2%) and an overall reduction of 16% (-32% to 2%)
- Admission rates for pedestrians aged 65 years and older decreased significantly from 26.8/100,000 in 1999 to 21.8/100,000 in 2008, representing an estimated annual decrease of 3.6% (95% confidence interval -6% to -1.2%) and an overall reduction of 30% (-46% to -11%). Figure 2







Emergency Department (ED) presentations

There were 4,685 ED presentations for traffic-related pedestrian injury recorded on the Victorian Emergency Minimum Dataset (VEMD) for the 10-year period 1999-2008, an average of 469 pedestrian ED presentations per year (range 409 to 553). Figure 3 shows the trend in frequency over the 10-year period but ED presentation rates are only provided for the final 5 years of the decade as all 38 hospitals offering a 24 hour ED service contributed data to the VEMD in this period.

Trend analysis found there has been a significant reduction in the frequency of ED presentations for pedestrian injury:

- The number decreased significantly from 553 in 1999 to 434 in 2008, representing an estimated annual decrease of 2.3% (95% confidence interval -3.9% to -0.9%) and an overall reduction of 21% (-33% to -8%). This is very similar to the reduction in the frequency of hospital admissions over the same period (i.e., 18%).

The trends in ED presentation rates were examined for the five-year period 2004 to 2008.

- Injury rates were fairly stable over the five-year period (8.2/100,000 in 2004 and 8.1/100,000 in 2008). This represents an estimated annual decrease of 0.2% (95% confidence interval -5.4% to 4.9%) and an overall decrease of 1.1% (-24% to 27%). This change is not statistically significant.

Male rates increased from 8.6/100,000 in 2004 to 9.2/100,000 in 2008 whereas female rates decreased from 7.9/100,000 to 7.1/100,000 over the same period. Neither of these changes reached statistical significance.

Over the 5-year period, ED presentation rates in pedestrians aged 15-24 years were 2-3 times the rates for the other 3 age groups (0-14, 25-64 and 65+ years). The rates for child pedestrians aged 0-14 years and adults aged 25-64 years were fairly stable over the period (children: 6.6/100,000 in 2004 and 6.2./100,000 in 2008; adults aged 25-64 years: 7.3/100,000 in 2004 and 7.1/100,000 in 2008). Among pedestrians aged 15-24 years ED presentation rates decreased non-significantly from 17.2/100,000 in 2004 to 15.9/100,000 in 2008 whereas in pedestrians aged 65 years and older rates increased non-significantly from 5.3/100,000 in 2004 to 7.2/100,000 in 2008.

Frequency of hospital-treated pedestrian injury by age group, Victoria 2006-2008 **Table 1**

INJURIES	HOSPITAL ADMISSIONS		ED PRESENTATIONS		ALL HOSPITAL-TREATED INJURIES	
	n	%	n	%	N	%
0-4yrs	53	2.5	30	2.3	83	2.4
5-9yrs	83	3.9	70	5.3	153	4.4
10-14yrs	104	4.8	90	6.8	194	5.6
15-19yrs	234	10.9	189	14.2	423	12.1
20-24yrs	212	9.9	188	14.1	400	11.5
25-29yrs	215	10.0	134	10.1	349	10.0
30-34yrs	140	6.5	92	6.9	232	6.7
35-39yrs	144	6.7	91	6.8	235	6.7
40-44yrs	108	5.0	67	5.0	175	5.0
45-49yrs	110	5.1	61	4.6	171	4.9
50-54yrs	107	5.0	56	4.2	163	4.7
55-59yrs	85	4.0	58	4.4	143	4.1
60-64yrs	84	3.9	45	3.4	129	3.7
65-69yrs	89	4.1	43	3.2	132	3.8
70-74yrs	96	4.5	36	2.7	132	3.8
75-79yrs	105	4.9	38	2.9	143	4.1
80-84yrs	100	4.7	29	2.2	129	3.7
85+ yrs	81	3.8	16	1.2	97	2.8
	2,150	100	1,333	100	3,483	100

Sources: VAED (hospital admissions): 2006-2008 and VEMD (ED presentations): 2006-2008

Detailed analysis (2006-8)

Data for the most recent available 3 years (2006-2008) were analysed in more detail. Over this period there were 3,483 hospital-treated pedestrian traffic-related injury cases (2,150 hospital admissions and 1,333 ED presentations), an average of 1,161 cases per year (717 hospital admissions and 444 ED presentations).

Gender

Fifty-nine percent of pedestrian hospital admissions were male (n=1,258) compared with 54% of ED presentations (n=716).

Age

Table 1 shows the frequency of hospital-treated pedestrian injury cases by 5-year age groups. The number of hospital-treated cases tended to increase as age increased in childhood, peaked in adolescents and young adults (aged 15-29 years) and then steadily decreased as age increased. The pattern was similar for admissions and ED presentations. Overall, pedestrians aged between 15 and 29 years accounted for around a third of hospital-treated injuries over the 3-year study period (n=1,172, 34%).

Rates: age and gender

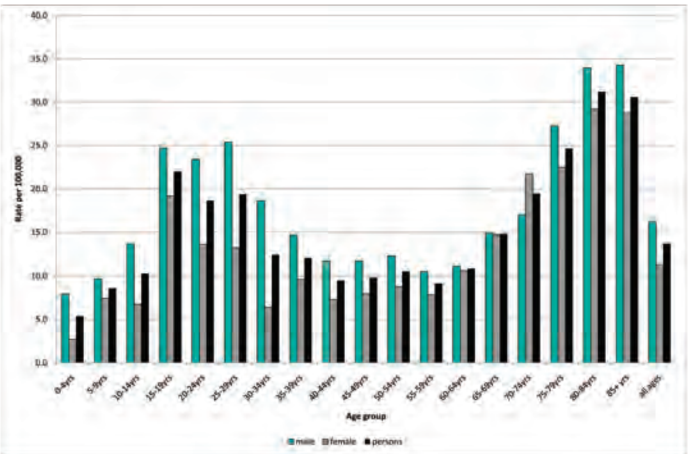
Age-specific pedestrian hospital admission rates were highest in older adults (Figure 4). Admission rates increased during childhood, were higher in adolescents and young adults aged 15-29 years than in adults aged 30 to 69 years and then peaked in older adults, especially in older pedestrians aged 80 years and over (Figure 4). Admission rates were higher in males than females in all age groups except in those aged 70-74





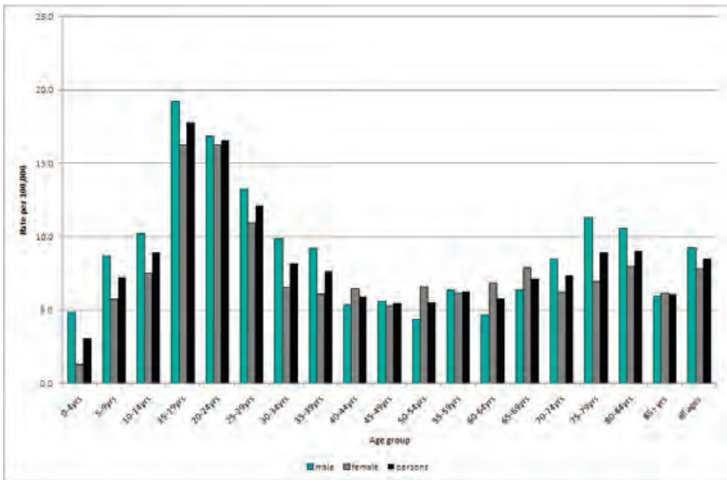


Average annual traffic-related pedestrian hospital admission rates by age and gender, Victoria 2006-2008 **Figure 4**



Source: Victorian Admitted Episodes Dataset (VAED)

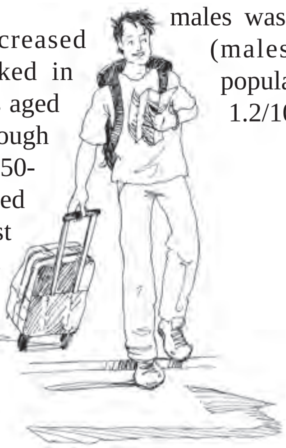
Average annual traffic-related pedestrian ED presentation rates by age and gender, Victoria 2006-2008 **Figure 5**



Source: Victorian Emergency Minimum Dataset (VEMD)

years. The difference between male and female rates was greatest in children aged 0-4 and 10-14 years and in young adults ages 20-24, 25-29 and 30-34 years.

ED presentation rates increased throughout childhood, peaked in adolescents and young adults aged 15-29 years then declined through all adult age groups until age 50-55 years when rates increased again, peaking in the oldest age groups. Whereas males had higher hospital admission rates than females in all age groups except people aged 70-74 years, females had higher ED presentations rates in five of the 5-year age groups, all from age 40 years. The gender gap was greatest in children aged 0-4 years where the risk of pedestrian hospitalization among males was four times that for females (males 4.8 admissions/100,000 population compared with females 1.2/100,000).



Ethnicity: language spoken and road convention in country of birth

Language mainly spoken in country of birth

Hospitalisations were distributed into three groups based on country of birth: Australian born; Overseas born: mainly English speaking countries; and Overseas born: non-English speaking countries (see Box 2 for selection criteria). As Figures 6 and 7 show, people born in mainly non-English speaking countries had the highest average hospital admission and ED presentation rates for pedestrian injury (17.8 admissions/100,000 and 10.9 ED presentations/100,000, respectively), followed by Australian-born people (11.4 and 7.6) and people born overseas in mainly English speaking countries (9.6 and 6.0).

Hospital admissions

For males, being born in mainly non-English speaking countries increased the risk of pedestrian injury. They had, respectively, 1.3 and 1.7 times the average annual pedestrian injury hospital admission rate of Australian-born males (17.9 compared with 14.2) and males born in mainly English speaking countries (17.9 compared with 10.8). Similarly, females born in mainly non-English speaking countries had around twice the average annual pedestrian injury hospital admission rate found for Australian-born females and females born in mainly English speaking countries (17.6 compared with 8.6 and 8.9, respectively). (Figure 6)

ED presentations

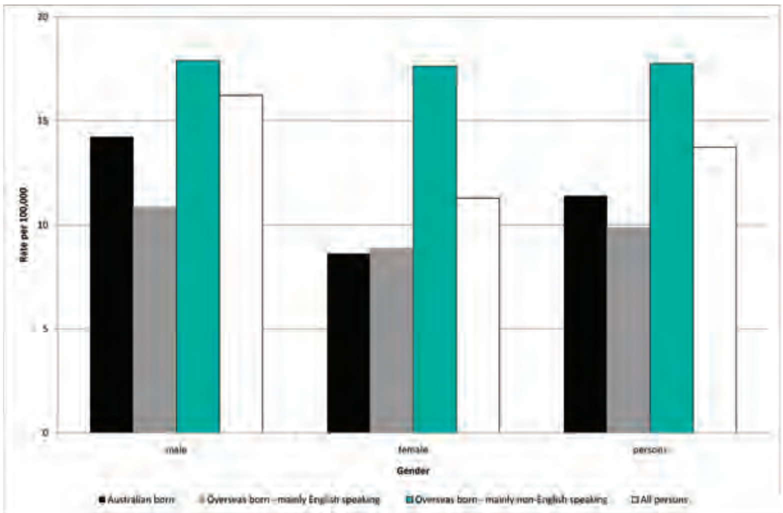
People born in mainly non-English speaking countries also had the highest average annual ED presentation rates for pedestrian injury, followed by people born in Australia and people born overseas in mainly English speaking countries (Figure 7). Females born in mainly non-English speaking countries had around twice the pedestrian injury ED presentation rate of Australian-born females and females born in mainly English speaking countries (11.6 compared with 6.5 and 5.9 respectively); males born in mainly non-English speaking countries had 1.2 and 1.7 times the pedestrian injury ED presentation rate of





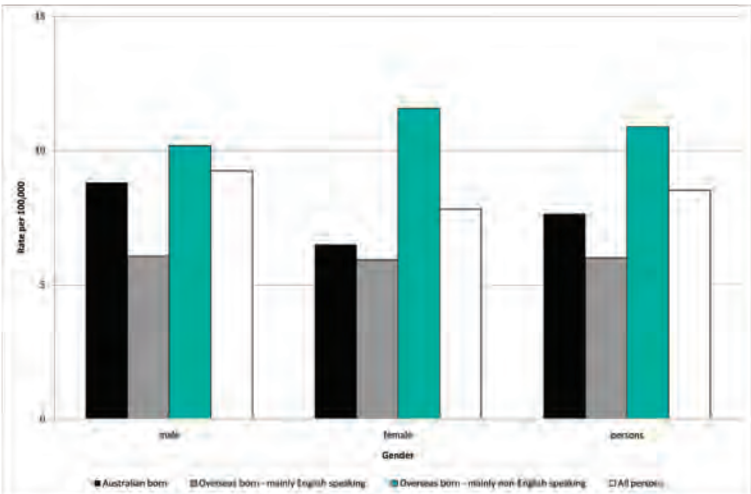


Average annual traffic-related pedestrian hospital admission rates by gender and language mainly spoken in country of birth, Victoria 2006-2008 **Figure 6**



Source: Victorian Admitted Episodes Dataset (VAED)

Average annual traffic-related pedestrian ED presentation rates by gender and language mainly spoken in country of birth, Victoria 2006-2008 **Figure 7**



Source: Victorian Emergency Minimum Dataset (VEMD)

Australian-born males and males born in mainly English speaking countries (10.2 compared with 8.8 and 6.0, respectively). (Figure 7)

Road convention of country of birth

The role played by road convention (left- or right-hand drive) in the person's country of birth was then investigated. As shown in Figures 8 & 9, people born in countries where the convention is to drive on the right side of the road had the highest average pedestrian hospital admission and ED presentation rates (19.3/100,000 and 11.7/100,000 respectively) followed by Australian-born people (11.4 and 7.6) and people born in countries where the convention is to drive on the left side of the road (11.3 and 7.1).

Hospital admissions

Males born in countries where the convention is to drive on the right side of the road have 1.3 and 1.5 times the pedestrian injury hospital admission rate than Australian-born males (19.1/100,000 compared with 14.2/100,000) and males born overseas in countries where the convention is to drive on the left side of the road (19.1 compared with 12.4). Females born in countries where the convention is to drive on the right side of the road have 2.3 and 1.9 times the pedestrian injury hospital admission rates for Australian born females (19.6 compared to 8.6/100,000) and females born overseas in countries where the convention is to drive on the left side of the road (19.6 compared to 10.2/100,000). Figure 8.

ED presentations

Males born in countries where the convention is to drive on the right side of the road have 1.2 and 1.6 times the pedestrian injury ED presentation rate than Australian-born males (10.9/100,000 compared with 8.8/100,000) and males born overseas in countries where the convention is to drive on the left side of the road (10.9 compared to 6.9/100,000). Females born in countries where the convention is to drive on the right side of the road have 1.9 and 1.7 times the pedestrian injury ED presentation rate for Australian-born females (12.5 compared with 6.5) and females born overseas in countries where the convention is to drive on the left side of the road (12.5 compared with 7.2). Figure 9.

Local Government Area (LGA) of residence

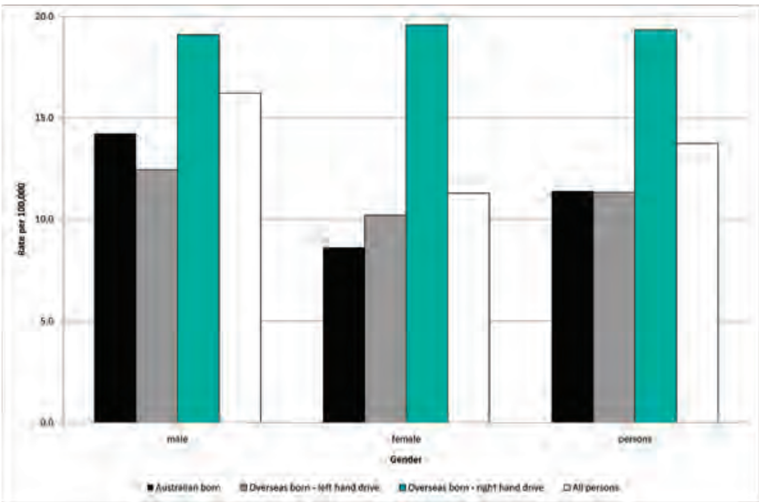
Information on the LGA in which the patient lived (derived from suburb and postcode of residence) is only available on the hospital admissions dataset. Pedestrian hospital admission rates were compared by LGA. The average (mean) pedestrian admission rate for the period 2006-8 for all Victorians was 13.7/100,000 population. The LGAs that had much higher admission rates (cut-off 20/100,000) were: Melbourne (30.5); Yarra (29.8); Port Phillip (29.3); Maribyrnong (26.9); Stonnington (26.6); Moreland (25.7); Darebin (22.8); and Greater Dandenong (21.0). There is no variable on the VAED to identify the





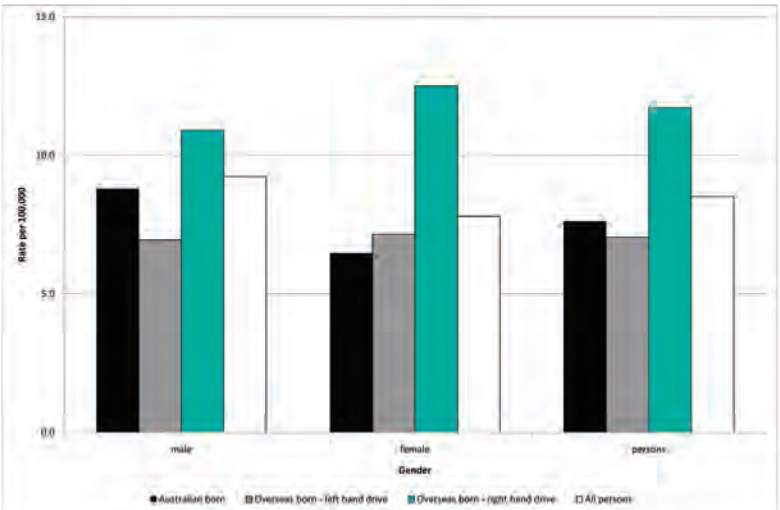


Average annual traffic-related pedestrian hospital admission rates by gender and road convention of country of birth, Victoria 2006-2008 — Figure 8



Source: Victorian Admitted Episodes Dataset (VAED)

Average annual traffic-related pedestrian ED presentation rates by gender and road convention of country of birth, Victoria 2006-2008 — Figure 9



Source: Victorian Emergency Minimum Dataset (VEMD)

postcode (and LGA) where the injury occurred.

Alcohol and drug involvement

Hospital admissions

Alcohol involvement in pedestrian hospital admissions was identified if cases contained either an alcohol-related diagnosis or external cause ICD code (see Box 2). It is likely that alcohol involvement is underestimated in injury cases recorded on the hospital admissions dataset. Two hundred and sixty-four alcohol-involved admissions were identified; 12% of pedestrian admissions. Of these, 14 admissions had more than one alcohol-related code. The most commonly used of the 24 identifying codes were: F10 Mental and behavioural disorders due to the use of alcohol (n= 236, 89%); and Z72.1 Alcohol use (n=21, 8%). The other used codes were: Y90 Evidence of alcohol involvement determined by blood alcohol level (n=14, 5%); Y91 Evidence of alcohol involvement determined by level of intoxication (n=3, 1%) and K70 Alcohol liver disease (n=5, 2%).

Of the 264 alcohol-related pedestrian admissions, 81% were male. Comparing 15-year age groups, pedestrians aged 15-29 years accounted for 44% of alcohol-related cases, followed by those aged 30-44 (32%) and those aged 45-59 (17%). The peak 5-year age group for alcohol-related pedestrian admissions was pedestrians aged 20-24 years (17%).

Seventy-four percent of alcohol-related admissions were Australian-born, 6% were born in other English-speaking countries and 10% were born in non-English speaking countries. Place of birth was unknown for 10% of cases.

Although most alcohol-related admissions were due to collisions with cars (89%), alcohol-related cases formed a higher proportion of pedestrian admissions that were caused by collisions with trams (31%) and trains (23%) than with cars (13%), trucks/buses (11%) and motorcycles (10%).

The use of psychoactive substances (opioids, cannabinoids, sedatives/hypnotics, cocaine and other stimulants, hallucinogens, volatile solvents and multiple or other psychoactive substances) were involved in at least 2% of pedestrian hospital admissions, almost exclusively found in persons aged 15-44 years.

Emergency department presentations

Alcohol involvement in ED presentations was identified by a text search of case narrative data (see Box 2). Only 31 cases were identified, 2.3% of pedestrian ED presentations. This low rate of alcohol involvement indicates significant under-reporting of alcohol involvement so no further analysis was undertaken.







Distribution of cases by season of year and day of week

Seasonal pattern

Table 2 shows the proportion of pedestrians injured in each season by age group and injury severity. Overall, a higher proportion of hospital-treated pedestrian injuries occurred in winter (28% overall, 27% of admissions and 28% of ED presentations) and autumn (27% overall, 27% of admissions and 27% of ED presentations) than in spring (24% overall, 25% of admissions and 24% of ED presentations) or summer (21% overall, 21% of admissions and 22% of ED presentations).

Pedestrians aged 75 years and older appear to be most at risk of injury in winter as one-third of all hospital treated cases in this age group occurred during winter (34% of admissions and 33% of ED presentations) compared with 15% in summer (15% of admissions and 18% of ED presentations).

Day of week

Overall, there was a fairly even distribution of pedestrian hospital admissions and ED presentations across the days of the week. However, analysis of data on the average number of hospital-treated injury cases over the weekdays compared with those that occurred on weekend days by age group showed that pedestrians aged 15-29 years and pedestrians aged 30-44 were more likely to be injured on a weekend day, whereas in the other age groups they were more likely to be injured on a weekday than a weekend day.

Vehicle type involved

As shown in Table 3, a very high proportion (89%) of hospital-treated injury cases were injured in collisions with cars, pickup trucks and vans (range: 85% of cases in age group 30-44 years to 93% in age group 0-14 years). Other forms of transport caused small proportions of injury cases. There were small variations in the type of vehicle involved by age group.

Crash circumstances

There are no data on crash circumstances for hospital admissions. ED presentations data on the VEMD contain a short narrative

Season of year in which traffic-related pedestrian injury occurred by age group, Victoria 2006-2008 **Table 2**

	0-14	15-29	30-44	45-59	60-74	75+	TOTAL
	%	%	%	%	%	%	%
HOSPITAL ADMISSIONS							
Summer	22.1	22.5	23.7	18.9	19.3	14.7	20.7
Autumn	28.8	23.6	29.1	29.1	31.2	25.5	27.2
Winter	20.8	26.9	25.0	29.5	28.6	33.6	27.3
Spring	28.3	26.9	22.2	22.5	20.8	26.2	24.7
ED PRESENTATIONS							
Summer	22.6	22.1	23.2	22.3	20.2	18.1	22.0
Autumn	30.5	24.1	28.8	26.9	25.8	27.7	26.6
Winter	22.1	30.3	26.4	26.3	28.2	32.5	27.8
Spring	24.7	23.5	21.6	24.6	25.8	21.7	23.6
ALL HOSPITAL-TREATED							
Summer	22.3	22.4	23.5	20.1	19.6	15.4	21.2
Autumn	29.5	23.8	29.0	28.3	29.5	26.0	27.0
Winter	21.4	28.4	25.5	28.3	28.5	33.3	27.5
Spring	26.7	25.4	22.0	23.3	22.4	25.2	24.3

Source: VAED & VEMD (2006-2008)

Vehicle type involved in traffic-related pedestrian collisions: all hospital-treated injury by age group, Victoria 2006-2008 **Table 3**

	0-14	15-29	30-44	45-59	60-74	75+	TOTAL
	%	%	%	%	%	%	%
ALL HOSPITAL-TREATED INJURY CASES							
Collision with car, pick-up truck or van	92.8	91.3	85.1	86.5	85.6	89.3	88.8
Collision with heavy transport vehicle (truck) or bus	1.3	1.8	3.1	2.5	3.8	3.4	2.5
Collision with 2 or 3 wheeled motor vehicle (m/cycles)	1.0	1.4	2.5	2.5	1.9	2.0	1.8
Collision with pedal cyclist	2.8	0.9	1.9	2.9	4.6	1.7	2.1
Collision with railway train or railway vehicle	0.3	0.7	1.9	1.1	0.3	0.0	0.8
Collision with other non-motor vehicle (includes trams)	0.3	1.6	2.0	0.7	0.5	0.3	1.1
Injured in other and unspecified pedestrian incident	1.8	2.3	3.6	3.8	3.3	3.4	2.9
All traffic-related pedestrian injuries	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: VAED & VEMD (2006-2008)







description of the injury event but they are of variable quality. The analysis of case narratives indicated that many more pedestrians were hit by slow-moving cars than by speeding vehicles. Commonly-mentioned circumstances in which pedestrians were injured in crashes were: when crossing the road; when playing on the road; when running or walking onto the road; when boarding/alighting trams; when walking behind reversing vehicles; when in car parks or driveways; and when on the road and hit by turning vehicles.

Injury type and body region

Nature of main injury

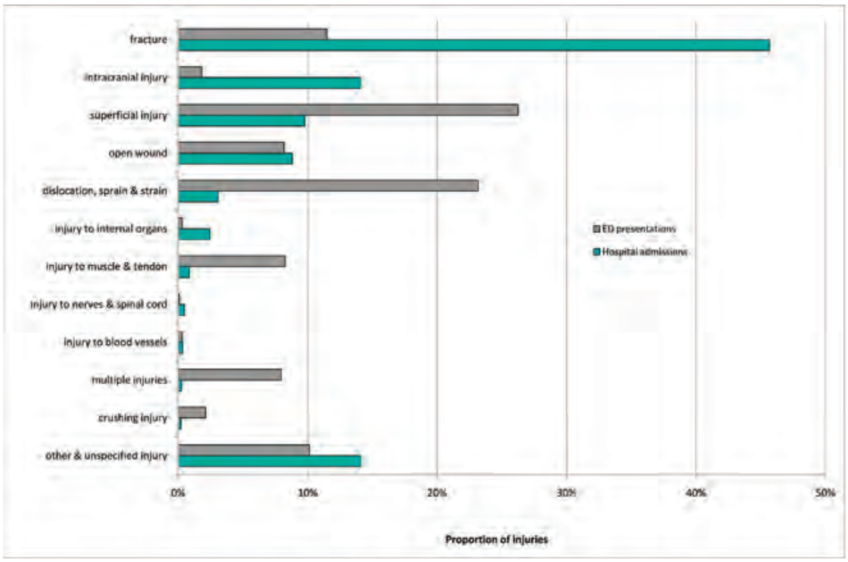
As shown in Figure 10, among hospital admissions the major injury types were fracture (46%) and intracranial (brain) injury (14%), whereas among ED presentations the major injury types were superficial injury (26%) and dislocations, sprains or strains (23%).

Fractures were the most common injury in all age groups but they formed a higher proportion of injuries as age increased from age group 30-44 years. Among admissions, intracranial (brain) injury was the second commonest injury, accounting for 14% of admissions but they formed a higher proportion of admissions in pedestrians aged 15-29 years (17%) and 30-44 years (18%) than in other age groups.

Body region injured

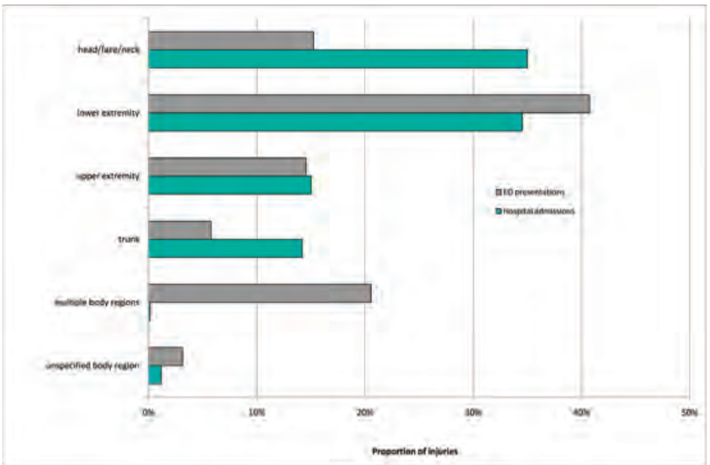
As shown in Figure 11, among hospital admissions the head, face and neck and the lower extremity were the most commonly injured body regions (both 35%), whereas among ED presentations lower extremity injuries were most frequent (41%) followed by injuries to multiple body regions (21%).

Injury type: traffic-related pedestrian injury, Victoria 2006-2008 **Figure 10**



Source: VAED & VEMD (2006-2008)

Body region injured: traffic-related pedestrian injury Victoria 2006-2008 **Figure 11**



Source: VAED & VEMD (2006-2008)

Length of stay in hospital (hospital admissions only)

Figure 12 shows the average (mean) length of stay for hospital admissions by gender and age group. Overall, the average length of stay was 4.9 days (5.0 days for males and 4.8 for females).

In general, the average length of stay increased with increasing age, with the exception that children aged 0-14 years had a longer average length of stay (3.6 days) than pedestrians aged 15-29 years (3.0 days). The youngest (0-14 years) and oldest (60-74 years and 75 years and older) females spent longer in hospital, on average, than their male counterparts, whereas among pedestrians aged 15-29 years, 30-44 years and 45-59 years, males had longer average lengths of stay than females. (Figure 12)

Injury severity (hospital admissions only)

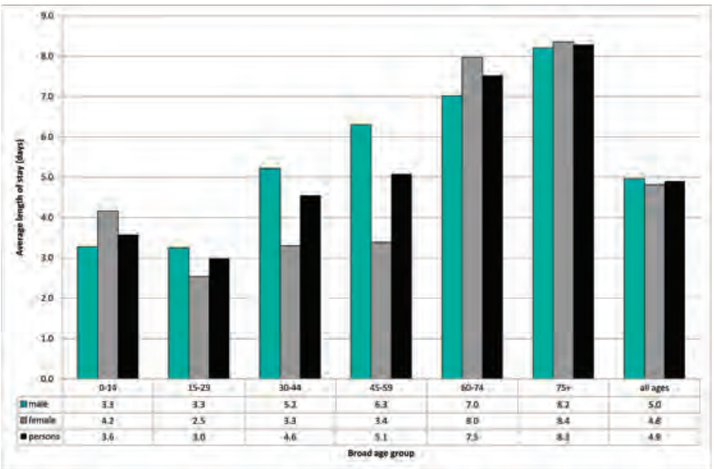
To examine the severity of pedestrian injury hospital admissions each hospital record was given an International Classification of Disease (ICD)-based Injury Severity Score (ICISS). The ICISS involves estimating the probability of death ('threat-to-life') using the ICD injury diagnosis codes recorded in a person's hospital record (see Box 2). An injury is defined here as 'serious' (high threat-to-life) if the ICISS score is less than 0.941. Injury of this severity is likely to





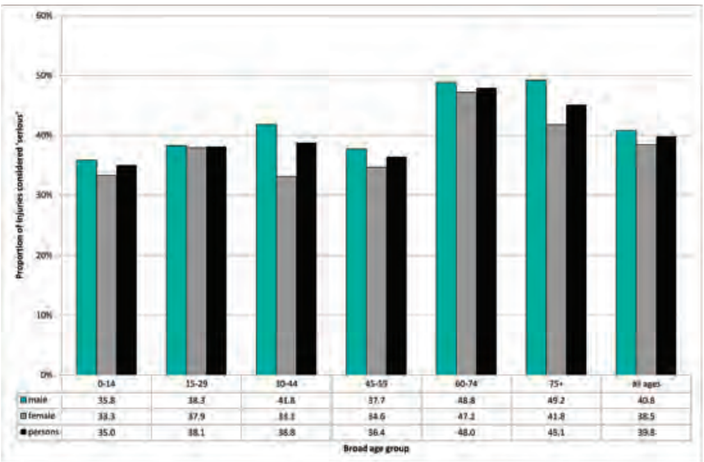


Average length of stay (days) of traffic-related pedestrian hospital admissions by gender and age group, Victoria 2006-2008 — Figure 12



Source: VAED (2006-2008)

Injury severity: proportion of traffic-related pedestrian hospital admissions classified as 'serious' by gender and age group, Victoria 2006-2008 — Figure 13



Source: VAED (2006-2008)

have a large effect on the patient in terms of persisting health problems and need for follow-up health care.

Figure 13 shows the proportion of pedestrian injury hospital admissions classed as serious by gender and age group. Overall, 40% of pedestrian hospital admissions were serious (41% of male cases and 39% of female cases). This is a much higher rate of 'serious' hospitalisations than found for all other unintentional injury causes combined (15%). The only broad injury cause that had a higher proportion of 'serious' hospital admissions was drowning (78%).

Comparing age groups, the proportion of serious cases generally increased as age increased. In all age groups the proportion of serious cases was slightly higher in males than females, with the gender imbalance most evident in age groups 30-44 years (males: 42%; females: 33%) and 75 years and older (males: 49%; females: 42 %). Figure 13.

Table 4 shows the proportion of injuries classed as 'serious' differed by the type of vehicle involved in the collision. With the exception of motorcycles, the mass of the vehicle involved in the pedestrian collision appears to influence the severity of injuries from the crash. Forty-one percent of hospitalised pedestrians that were involved in collisions with cars, pick-up trucks or vans (the commonest crash) were 'seriously' injured, compared with 65% of pedestrians involved in collisions with railway trains or vehicles, 56% of pedestrians involved in collisions with other non-motor vehicles (including trams) and 45% of pedestrians involved in collisions with heavy transport vehicles or buses. Pedestrians injured in collisions with motorcycles were more likely to be 'seriously' injured than those injured in collisions with cars (44% compared with 41%), whereas those injured in collisions with bicycles were much less likely to be 'seriously' injured (26%). None of the pedestrians hospitalised after colliding with pedestrian conveyances were seriously injured.





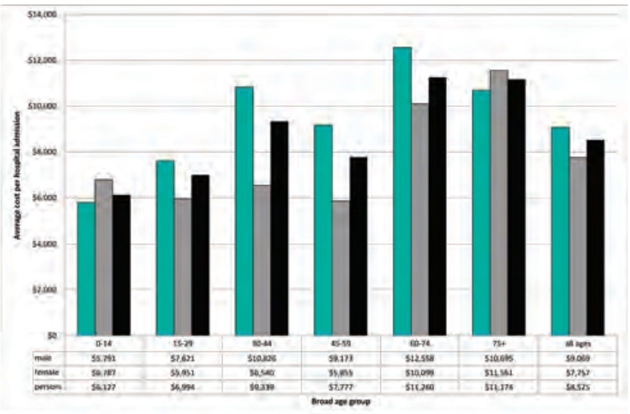


Traffic-related pedestrian hospital admissions: vehicle type and injury severity, Victoria 2006-2008 — Table 4

SPECIFIC CAUSE OF INJURY	% CASES CLASSIFIED AS 'SERIOUS'	FREQUENCY
Collision with railway train or railway vehicle	65.4%	26
Collision with other non-motor vehicle (includes trams)	56.3%	16
Collision with heavy transport vehicle or bus	44.6%	56
Collision with 2 or 3 wheeled motor vehicle (motorcycle)	43.8%	48
Collision with car, pick-up truck or van	40.6%	1,875
Collision with pedal cyclist	25.7%	35
Collision with pedestrian conveyance	0.0%	6
Injured in other and unspecified pedestrian incident	18.9%	88
All traffic-related pedestrian injury cases	39.8%	2,150

Source: VAED (2006-2008)

Average (mean) hospital costs of traffic-related pedestrian hospital admissions by gender and age group, Victoria 2006-2008 — Figure 14



Source: VAED (2006-2008)

Cost of injury (hospital admissions only)

Each hospital admission was assigned an Australian Refined Diagnosis Related Group (AR-DRG) which is a patient classification system that provides a clinically meaningful way of relating the types of patients treated in a hospital to the resources required by the hospital. The National Hospital Costs Data Collection (NHCDC) produces average costs for each AR-DRG by state (for further information see Box 2).

The total hospital costs of pedestrian admissions over the three years 2006-2008 was $18,328,000 or $6,109,000 per year. The average (mean) cost per admission was $8,525 (range: $698 to $85,219).

Figure 14 shows the average hospital cost of admissions by gender and age group. The average cost per admission peaked in those aged 60-74 years ($11,260), closely followed by those aged 75 years and older ($11,174). Overall, the average costs per admission for males was higher than for females ($9,069 compared to $7,757). The youngest (0-14 years) and oldest (75 years and older) females had higher average costs per admission than their male counterparts, whereas for age groups 15-29 years, 30-44 years, 45-59 years and 60-74 years, males had higher average costs per admission than females.

The average cost per pedestrian hospital admission was compared to the average cost of all unintentional injury admissions and to the average cost of other causes of unintentional injury. The average cost per admission for all causes of unintentional injury was $4,721. The only broad cause of injury group that had a higher average cost per admission than traffic-related pedestrian injury was choking and suffocation ($10,291 per admission).







Discussion

Although there were encouraging decreases in the frequency (18%) and rate (29%) of traffic-related pedestrian hospital admissions in Victoria over the decade 1999-2008, much of the decline occurred between 2002 and 2005. In 2006 the number and rate of pedestrian admissions increased sharply (back to the levels seen in 2004) and have stabilised at this higher level since.

The decline in serious pedestrian-vehicle crashes around 2002 has been attributed to the reduction in the default speed limit on residential streets from 60km/hr to 50km/hr, introduced in Victoria in January, 2001 and a strengthened approach to enforcing driver and rider compliance with speed limits, introduced in early 2002 (Haworth et al., 2005; Hoareau et al., 2006; Corben, 2007). The enforcement intervention included an extensive package of measures such as an increase of 50% in speed camera enforcement hours and a reduction in the size of the enforcement tolerance values exercised by Police (Haworth et al., 2005). However, the gains from these interventions have been absorbed and new actions appear needed to generate further reductions in pedestrian trauma.

We currently have sparse information on whether pedestrian exposure to traffic increased over the decade of interest. The Australian Bureau of Statistics (ABS) Census of Population and Housing provides some pertinent, though limited, data (Bartley Consulting, 2008). Specifically the 1996, 2001 and 2006 Censuses, asked how the respondent got to work on a selected day (Tuesday, August 6, 1996/Tuesday August 7, 2001/Tuesday August 8, 2006). Results show that the number of journeys (trips) to work by walking increased from 63,668 in 1996 through 64,732 in 2001 to 80,539 in 2006. However, most of the growth in the number of journeys to work occurred in metropolitan Melbourne, originating in the inner suburbs and ending in and around the CBD.

There will be more comprehensive exposure data in the future. The Department of Transport's biennial survey, the Victorian Integrated Survey of Travel and Activity (VISTA), will provide a detailed picture of changes to the exposure of people in Melbourne, Geelong, Ballarat, Bendigo, Shepparton and Latrobe to the different travel modes (measured in trips taken and distance travelled) on an average day. The results of the 2007 survey (VISTA 07) were only recently published and the VISTA 09 is in progress. However, for a more detailed picture we need to incorporate regular pedestrian monitoring systems into our current traffic monitoring systems in high risk areas, for example vehicle data are collected routinely at almost all signalized intersections in Melbourne yet pedestrian data collection is sporadic and usually confined to areas such as the CBD.

Risk factors

The risk factors for pedestrian injury are usually categorised as shown in the table below. The potential risk factors identified in our descriptive study will be discussed in the context of the findings from other studies undertaken in Australia and developed overseas countries. In the discussion to follow the categories have been collapsed to four: human, vehicle, environment and crash.

Category	Risk factors
Demographic	Age, gender and ethnicity of pedestrian and vehicle driver
Socio-economic Behavioural	Area and individual SES indicators - deprivation indices, employment status, marital status, income level and education achievement Drug and/or alcohol intoxication and pedestrian and driver unsafe/ illegal behaviour
Vehicle-related	Type, mass (weight) and frontal design
Roadway-related	Hierarchy, road geometry, geometric design, traffic control and speed limit
Environment-related	Temporal factors (time of day, season of year) and weather conditions
Crash-related	Impact speed, crash type, and pedestrian movement
Urban /transport planning-related	Urban land use, transport facilities and policies
Combination	Combination of above factors

Human factors

Age

Our study showed that the number of hospital-treated pedestrian injury cases peaked in young people aged between 15 and 29 years. Hospitalisation rates, however, were highest in those aged 75 and older, followed by those aged 15 to 29. Consistent with these results, other Australian studies (Holubowycz, 1995; ATSB, 2002; Small et al., 2006) and descriptive studies from comparable countries such as the US, Ireland, France and Singapore have found that older people (age 65 years and over) are over-represented in fatal and severe pedestrian crashes (Fontaine and Gourlet 1997; Harruff et al. 1998; Peng & Bongard 1999; Zajac and Ivan 2003; Demetriades et al. 2004; Sze and Wong 2007; Eluru et al. 2008; Clifton et al. 2009; Martin et al., 2009; Loo & Tsui, 2009). We did not find any evidence of a relationship between age and body region injured unlike the trauma registry study conducted in the US by Demetriades et al (2004). The authors reported that the incidence of severe head injury, chest trauma, and spinal injury in pedestrian crashes increases with age, with patients older than 65 years most at risk of severe injury at these anatomical sites (Demetriades et al., 2004).

The observed higher death and hospitalisation rates in older pedestrians have been linked to a number of direct factors such as their reduced ability to deal with complex traffic situations and slower walking speed and indirect factors such as their greater frailty and the higher likelihood of underlying health conditions in older age including dementing diseases (Oxley et al., 1997; Oxley et al., 2005).

Ageing has consequences on sensory, visual, perceptual and cognitive abilities that can adversely affect road crossing performance. Even though there is evidence that older people seek to offset age-related sensory and cognitive declines by reducing exposure and adopting more cautious behaviours (Oxley et al., 1997; Charlton et al., 2006), some older pedestrians experience difficulty when demands are complex, for example when selecting safe gaps in traffic when crossing the road (Oxley et al., 2005).







The over-representation of 15 to 29 year-olds in pedestrian hospitalisations and ED presentations is possibly explained by their higher pedestrian exposure as they become independently mobile and, perhaps, alcohol and drug involvement, but other unknown factors may play a role. The risk factors for pedestrian injury in this age group require further investigation.

Our study found that hospitalisation rates among child pedestrians were lower than those in most other age groups. Similar findings have been reported from some overseas countries (Peng & Bongard, 1999; Demetriadis et al. 2004; Sze and Wong, 2007) but not others (Clifton et al., 2009; Fontaine & Gourlet 1997; Al-Ghamdi, 2002). Conflicting study results may be explained by the reduction of exposure to traffic among Australian children and children in some other Western countries due to the decline in walking trips in this age group and a concomitant increase in car trips. Surveys conducted in Australia and elsewhere indicate that reduced walking for transport among children is due to the convenience and 'culture' of car use, parental and child fears about road traffic trauma and street crime, and the increased distance from home of schools, shopping centres and recreational facilities (Timperio et al., 2004; Giles-Corti et al., 2009; Lorenc et al., 2008 - review).

Current Victorian public health initiatives such as *Kids go for your life – stride and ride* that encourage children to walk and cycle to school and other destinations in their local neighbourhood have the potential to increase their injury risk unless environmental measures are put in place to make these modes of active travel safer and the road environment more forgiving of children's crossing 'errors'. For example, an evaluation study by Delaney at al. (2005) showed that the *Safe routes to school* community based road safety programs in Victoria that include education, engineering, encouragement and enforcement initiatives, aimed principally at reducing casualty crash frequency and severity for children as pedestrians, bicyclists and passengers, reduced pedestrian casualty crashes by about 17%. Research indicates that ages 7 to 11 are the most formative years for the development of road crossing skills and that children aged below 10 have relatively poor skills at reliably setting safe distance gap thresholds and thus do not consistently make safe crossing decisions (Connelly et al., 1998; Thomson et al., 2005; Oxley et al., 2007).

Gender

Our study showed that the frequency and rate of hospital-treated pedestrian injury is higher among males than females. This observed gender difference is well supported by other Australian studies (Holubowycz, 1995; Small et al., 2006) and overseas research (Bradbury, 1991; Harruff et al. 1998; Beck et al. 2007; Mabunda et al. 2008; Clifton et al. 2009).

Among hospital admissions we found that males were more likely than females to suffer high 'threat-to-life' injury and have a longer average length of hospital stay. These differences, however, were small. Our findings are in partial agreement with the results of a US study of around 7,000 patients admitted to a Level 1 trauma centre (Starner et al., 2008). The authors reported that gender had no effect on survival or intensive care unit (ICU) stay but that male patients aged 15-65 years had a significantly longer hospital stay. By contrast, Sze and Wong (2007) reported from their large study of pedestrian casualties in traffic crashes in Hong Kong, that females were significantly more likely to suffer harsher injury outcomes than males when involved in pedestrian-vehicle crashes.

Ethnicity and Indigenous status

This study categorised people born in other countries according to the language (mainly English-speaking and non-English speaking) and the road convention (left hand side, right-hand side) of their country of birth. We found that people born in mainly non-English speaking countries and those born in countries where the road convention is to drive on the right were at higher risk of pedestrian injury than Australian-born people, people born in mainly English speaking countries and those born in countries where the road convention is to drive on the left.

A small number of Australian studies have previously investigated the effect of ethnicity and Indigenous status on pedestrian crash risk. Similar to our study, an Australian study of national pedestrian fatality data and NSW pedestrian hospitalisations by Dobson and colleagues (2004) identified that pedestrians born in countries with a right hand driving convention, but not those born in countries with a left hand driving convention, were at significantly greater risk of being hospitalised or dying on the road when compared with Australian-born pedestrians.

The difference in risk was greatest for pedestrians aged 60 years and over born in countries with a right hand driving convention who had around twice the risk of being killed or injured as pedestrians compared to Australian-born people in the same age group. The authors concluded that road convention appeared to have a greater influence on pedestrian safety than language in country of origin and speculated that pedestrian behaviour (looking to the left or right) is learnt at an early age and may be difficult to change.

Because of small numbers and other considerations it was not possible for us to investigate whether Indigenous status affected pedestrian injury risk. Harrison & Berry (2008) studied fatal and injurious land transport (motor vehicle and train) accidents that occurred in the five-year period 2001-02 to 2005-06 in four Australian jurisdictions: Queensland, Western Australia, South Australia and the Northern Territory. The overall incidence of pedestrians being killed in land transport accidents was nine times as high for Indigenous people as for non-Indigenous people (11 compared to 1 per 100,000) and close to four times as high for hospitalisations (61 compared to 16 per 100,000). Data from Victoria, NSW, Tasmania and the ACT were not included in the study because the identification of Indigenous cases in the data sources used was not considered to be of acceptable quality (Harrison & Berry, 2008).

Socio-economic status (SES)

In the last issue of Hazard, the relationship between the SES of an area in which a person lives and their risk of hospital admission







for all external causes (mechanisms) of injury was investigated (Clapperton & Cassell, 2010). Although people living in the most disadvantaged of Victorian local government areas (LGAs) were significantly more likely to be hospitalised for transport injuries than those living in the least disadvantaged LGAs, further investigation revealed that this was due to their higher risk of car occupant and motorcycling injury rather than pedestrian or bicycling injury. No significant relationship between area deprivation and pedestrian injury was found in any age group.

By contrast, a recent study in NSW (Poulos et al., 2007) and studies conducted in the US, England and Wales all demonstrated that area deprivation increases the risk of child hospitalisation for pedestrian injury (Durkin et al., 1994; Lyons et al., 2003; and Hippsley-Cox et al., 2002; Graham & Stephens, 2008). The Welsh study also found that people of all ages living in deprived areas were at increased risk of pedestrian injury (Lyons et al., 2003).

In a UK study, Hewson (2004) assigned a deprivation measure to the location where the collision between the vehicle and pedestrian was reported and the home postcode of the child casualty. His results suggest that the deprivation measures of the area around the collision is a more important determinant of SES differentials in child pedestrian casualty risk than the deprivation measures of the injured children's home location (postcode of residence).

Several overseas studies on the relationship between pedestrian casualties and SES that utilised individual-level SES measures such as income level, employment status, marital status and education achievement also support the deprivation hypothesis. LaScala et al. (2000) showed that unemployment and low education level were associated with increased pedestrian injury rates in the City of San Francisco. Ryb et al. (2007) compared injured pedestrian casualties with casualties injured in other accidents and found that pedestrian casualties are more likely to be unmarried, unemployed and have lower income and education achievement.

Alcohol misuse

There is sparse research on the effects of alcohol impairment on the specific skills required to cross roads safely. Results from a pilot case control study conducted under experimental conditions in a simulator suggest that selecting safe gaps in traffic, a crucial pedestrian skill, may be compromised in intoxicated pedestrians (Oxley et al., 2006). Highly intoxicated study participants showed some lack of awareness of impairment, a tendency to engage in risky road crossings and difficulty integrating speed and distance information in a timely manner (Oxley et al., 2006).

Drivers and riders are subject to a legal blood alcohol limit whereas pedestrians are not. A BAC greater than 0.10% is generally classified as intoxicated. Intoxication by alcohol and drugs has been shown in a number of Australian and overseas studies to be a major contributory factor to pedestrian deaths and serious injury, especially among young males (Holubowycz, 1995; ATSB, 2003; Cairney et al., 2004; Small et al., 2006: Hutchinson et al, 2010). Road safety statistics on the Victorian Transport Accident Commission (TAC) website reveal that 26% of the 50 pedestrians who were killed in pedestrian-vehicle crashes in Victoria in 2009 had a BAC of at least 0.05g/100ml (http://www.tacsafety.com.au). An early Victorian study of alcohol involvement in Victorian pedestrian casualty crashes recorded on the VicRoads database during the 10-year period 1985-94 reported that 27% of the 4,400 cases where BAC was known had a reading in excess of 0.01g/100 ml (Corben et al., 1996).

Our study found that at least 12% of the 2,150 traffic-related pedestrian hospital admissions in Victoria in 2003-5 were alcohol-related, based on the use of the range of ICD-10-AM codes indicating alcohol involvement on the VAED. BAC levels were only recorded in a few cases. All Victorian public and private hospitals contribute data to the VAED.

We used the same method for identifying coded alcohol-related cases as was used in a recently published alcohol study by McKenzie and colleagues (2010) that sought to identify alcohol involvement in injury hospitalisations by examining a stratified random sample of 4,373 injury hospitalisations drawn from 50 hospitals across four states of Australia, including Victoria. The study compared the proportion of alcohol-related cases identified using ICD-10 alcohol codes to those identified in a manual medical record review and found that routinely collected data only identified 38% of the alcohol-related injury cases and, more specifically, 26% of the alcohol-related transport injury cases. The proportion of alcohol-related pedestrian transport cases was not estimated due to small numbers but their findings suggest that our result (12% alcohol-related) is likely a gross underestimation of alcohol involvement in traffic-related pedestrian hospitalisations in Victoria.

The other two Australian studies that have investigated the extent of alcohol involvement in hospital-treated pedestrian injury are single hospital studies, so their results are subject to bias. Holubowycz, (1995) reported that 28.6% of the 217 adult pedestrians (aged 16 years and older) admitted to a level 1 trauma hospital in Adelaide over a period of nearly two years recorded a BAC of 0.10g/100mL or above. In South Australia, the taking of blood for the determination of BAC is mandatory under the provision of the Road Safety Act for all injured pedestrians at or above the age of 14 years who present to hospital EDs within eight hours following involvement in a crash.

Small et al (2006) found a much higher proportion of intoxicated cases among pedestrians admitted as inpatients to an inner Sydney hospital during the years 2002-2004. Of the 180 adult pedestrian trauma patients with measured BAC, 49% tested positive for consuming alcohol, with an average BAC of 0.22%. Forty-three percent had a BAC greater than 0.10%. This study also found that alcohol consumption was associated with a worse outcome in terms of hospital and intensive care stay, morbidity and mortality.

There are no codes on the VEMD to identify alcohol involvement in pedestrian ED presentations and our text search found that alcohol involvement was poorly reported in case narratives. In Victoria, only a low







proportion of injured pedestrians have blood samples taken for a BAC reading in the emergency department. Section 56(2) of the Victorian Road Safety Act 1986 permits the taking of blood specimens by a doctor or an Approved Health Professional (AHP) from any person of or above 15 years of age who is involved in a motor vehicle accident and is brought to a place for examination or treatment.

Although the Victoria Police Drug and Alcohol Section interpret this provision as meaning that ED doctors and AHPs should take blood for drug and alcohol testing from all road crash victims, there is no legal requirement for doctors to do so except, on the Coroner's instruction, if the person is involved in a fatal vehicle accident and treated at a hospital (whether a driver, rider, passenger, pedestrian or cyclist).

In 1991 Victorian medical practitioners adopted a 'code of practice' in which it is policy to take blood specimens from all motor vehicle drivers and motorcycle riders involved in motor vehicle crashes. However, it is not usual practice for ED medical staff to take blood samples from injured pedestrians or bicyclists as police are more interested in the BAC of drivers involved in crashes. Even if blood specimens are taken in the emergency department, laboratory testing is performed off-site (currently at the Victorian Institute of Forensic Medicine - VIFM) and the results are not routinely reported back to hospitals and entered onto hospital injury surveillance datasets.

Available evidence indicates that a substantial proportion of pedestrians killed or seriously injured in motor vehicle crashes on our roads are under the influence of alcohol and/or drugs. It would assist prevention efforts if blood samples were routinely taken from injured pedestrians in the ED and a system set up to enter the results of blood tests on hospital injury surveillance datasets (either by the individual hospitals or later by the Department of Health where data are collated) for prevention and research purposes.

Attitude and behaviour of pedestrians and drivers

Hospital datasets provide no or very limited information on the circumstances of pedestrian injury, including the attitude or behavioural factors that may have contributed to pedestrian-vehicle crashes.

Attitude and behaviour of pedestrians

Aside from risky drinking and drug taking, pedestrians can place themselves at risk by crossing inappropriately, failing to obey traffic signs and road rules and being inattentive. A recent observation survey of pedestrian behaviour was conducted at signalised intersections in the Brisbane CBD on typical workdays, using behavioural categories that were identifiable in police crash reports (King et al., 2009). Illegal crossing types (crossing against flashing or steady red man and crossing away from but within 20 metres of signals) accounted for 20% of all observed crossings.

The observation data were then used as the measure of exposure when calculating the risk associated with illegal crossing using 11 years of pedestrian-vehicle crash data from the observation sites and adjacent midblocks. Illegal pedestrian crossings were found to be involved in over 58% of crashes. This is greater than the 32-44% reported earlier by Austroads (2000). However, the Austroads study (based on NSW crash data) did not include mid-block crashes. The authors of the Brisbane study estimated that crossing against the lights and crossing close to the lights both exhibited a crash risk per crossing event approximately eight times that of legal crossing at signalised intersections (King et al., 2000).

There is emerging evidence that distractions such as mobile phone and headphone use also increase the risk of pedestrians being involved in crashes. An observational field survey of 270 females and 276 males conducted in NSW compared the safety of crossing behaviours for pedestrians using versus not using a mobile phone (Hatfield & Murphy, 2007). The results suggest that mobile phone use while crossing the road may result in some unsafe behaviours that are gender specific. Female pedestrians who crossed while talking on a mobile phone crossed more slowly, and were less likely to look at traffic before starting to cross, to wait for traffic to stop, or to look at traffic while crossing, compared to matched controls. For males, those who crossed while talking on a mobile phone crossed more slowly at unsignalised crossings than males that crossed without mobile phones.

Further evidence is provided by observation and simulation studies conducted in the U.S (Stavrinos et al., 2009; Nasar et al., 2008; Bungum et al., 2005). In these studies, cognitive distraction by mobile phone or portable media player use was found to reduce situation awareness and increases unsafe road crossing behaviour in pedestrians. Study authors recommend that messages explicitly suggesting techniques for avoiding mobile use while road crossing may benefit pedestrian safety.

Attitude and behaviours of drivers

There is evidence to support the proposition that the attitude and behaviour of drivers increase the risk of pedestrian crashes, including the underlying perception among some drivers that vehicles have higher status on roadways than pedestrians. This results in unsafe driver behaviours such as refusal to give way to pedestrians, even when they are on pedestrian crossings, and speeding in high pedestrian activity areas (Al Ghambi, 2002; Preusser et al., 2002; Lee & Abdel-Aty, 2005).

Local research has shown that the probability of an injury and the severity of injury increases exponentially with vehicle speed and even a small increase in speed can result in a dramatic increase in impact forces experienced by crash victims, especially in unprotected road users such a pedestrians and bicyclists. Corben et al. (2006) constructed a mathematical model to predict the impact of speed on the risk of death to a pedestrian by comparing the stopping distance of paired vehicles travelling at different speeds. From these comparisons it was found that the risk of death to a pedestrian is strongly related to driver speed choice and that small reductions of the order of 5-10 km/h can produce substantial to major reductions in







risk. The model predicted that drivers of vehicles who choose to travel at 50 km/h in a high pedestrian activity area expose pedestrians who might attempt to cross within the vehicle's minimum stopping distance to, on average, a four-fold increase in the risk of death compared with drivers whose travel speed choice is 40 km/h.

Uncertainty about right-of-way rules among pedestrians and drivers may also play a role in pedestrian crashes. Hatfield and colleagues (2007) recently conducted an observational study of 2,854 pedestrians crossing at signal controlled intersections in NSW and an associated survey of beliefs of drivers and pedestrians about who has right-of-way in a range of pedestrian road crossing situations. Both behavioural observation and survey results indicated that there was some misunderstanding among both groups about who has right of way on various pedestrian crossing types.

The two most concerning areas of confusion were that a significant proportion of drivers of turning vehicles were not aware that they must give right-of-way to pedestrians even when their vehicle is facing a green signal, irrespective of the pedestrian signal, and a significant proportion of pedestrians mistakenly believed that they had right-of-way when waiting to enter a zebra crossing. The authors recommended that pedestrian crossing types should be rationalised (eliminating 'unofficial' crossings implied by the installation of refuges and distinctive paving treatments) and education provided to both pedestrians and drivers regarding rules and responsibilities at 'official' crossings.

Driver distraction by infotainment technologies (cell phone use, texting and use of portable media players) also appears to degrade driver performance and thereby increases the risk of vehicle–pedestrian crashes. Well-designed studies conducted in Toronto (Redelmeier & Tibshirani, 1997) and Perth (McEvoy et al., 2005) of the effect of cell phone use on crash risk found that a driver's use of a cell phone up to 10 minutes before a crash was associated with a fourfold increased likelihood of a crash. These studies used cell phone company billing records to verify phone use by crash-involved drivers.

Texting while driving has been shown in experimental studies to pose a greater risk to pedestrian safety than cell phone use (Drews et al., 2009; Olson et al., 2009). An Australian telephone survey conducted in 2003 found that one in six drivers regularly sent text messages while driving (Telstra, 2004). Simulator studies involving young drivers as subjects suggest that texting and operating iPods when driving puts pedestrians at greater risk of crashes (Chisholm et al., 2008; Hosking et al., 2009; Drews et al., 2009).

Recent changes by VicRoads (2009) to the Victorian road safety rules, consistent across Australia, prohibit the use of a mobile phone while driving except to make or receive a phone call or to use its audio/music functions and only if the phone is secured in a commercially designed holder fixed to the vehicle or can be operated by the driver without touching any part of the body of the phone and is not resting on any part of the driver's body. All other functions (including video calls, texting and emailing) are prohibited and Learner and P1 drivers are prohibited from using a mobile phone at all while driving.

The effectiveness of these regulations will depend on driver compliance which, in turn, is highly correlated to the level of police enforcement (Shults et al., 2004; Delaney et al., 2006). There is also evidence that phone conversations, whether by hand-held or hands-free devices, degrade driving to some extent so it is important that the more stringent Victorian regulations controlling mobile phone use are evaluated for effectiveness (McCarrtt et al., 2006, review).

Vehicle factors

Vehicle size, type (design) and weight

Our study found that, except for motorcycles, the mass of the vehicle colliding with the pedestrian impacted on injury severity. Research indicates that vehicle size, weight and type (design) are the chief determinants for the severity of injury to pedestrians in motor vehicle collisions (Desapriya et al., 2010-review; Chalabi et al., 2008; Chang & Wang, 2006; Rifaat & Chin 2007). There is substantial evidence that the recent changes in the composition of the global vehicle fleet, especially the explosion in the purchase of larger vehicles such as light truck vehicles (LTVs), including sports utility vehicles (SUVs), minivans and pickup trucks, in many countries, including Australia, pose a greater threat to pedestrians (Desapriya et al., 2010 - review).

LTVs (including SUVs) cannot be separately identified on hospital injury surveillance databases. A recently published meta-analysis and systematic review of high quality research investigating the relative risk of pedestrian injury in collisions with light truck vehicles (LTVs) compared with conventional passenger cars found that the likelihood of pedestrians sustaining fatal injury is 50% greater in collisions with LTVs than in collisions with conventional cars (Pooled OR 1.54, 95% CI 1.15-1.93) (Desapriya et al., 2010 - review).

The aspects of LTVs that have been identified as related to injuries sustained by pedestrians are their greater mass, the geometry and increased stiffness of the front end and the high position of the bumper (Desapriya et al., 2010 - review; Roudsari et al., 2005). Studies in North America and Europe have identified design modifications to the front (including upper bonnet and bumper), side and rear that would reduce the harm potential of LTVs to pedestrians (Desapriya et al., 2010 - review). It is estimated that fitted rigid bull bars, a feature of many LTVs and heavy trucks may contribute to an estimated 12-20% of fatal pedestrian crashes on urban roads in Australia (FORS 1996).

The proliferation of motorcycles on our roads also has the potential to increase pedestrian injury risk. We found that pedestrian collisions with motorcycles resulted in a higher proportion of serious injury than collisions with cars. According to the ABS 2009 Motor Vehicle Census, in Victoria registrations of motor cycles at 31 March 2009 were 44% above those recorded five years earlier (ABS, 2009). A study of the 4,857 pedestrian fatalities in the US in 2002 by Paulozzi (2005) found that 46% of deaths were related to crashes with passenger cars, 39% to light trucks, and 15% to motorcycles, buses and heavy trucks. After adjusting for distance







travelled by different vehicle types (i.e. risks per mile), compared with cars the relative risk of pedestrian death was nearly 12 times higher in pedestrian crashes with buses, nearly four times higher in crashes with motorcycles, 1.5 times higher for light trucks and not significantly different for heavy trucks.

The increased risk that a motorcycle has of killing a pedestrian had not been noted before and the author suggested that rider behaviours and lower visibility to the pedestrian of a motorcycle compared with a car may be contributory factors (Paulozzi, 2005). Proffered explanations for the observed greater risk to pedestrians posed by buses were their operation in close proximity to pedestrians and perhaps some bus and stop design features.

The review by Desapriya et al. (2010) canvasses current initiatives being taken by the European Commission (EC), various vehicle standards and testing organisations and the US government to develop vehicles with safer front ends and greater energy absorption properties and to encourage and, if necessary, require carmakers to implement new safety standards to reduce the risk of pedestrian trauma.

Environmental factors

Temporal factors: time of day, day and month, season of year

Our study found that hospital-treated injury cases were spread fairly evenly across the days of the week but that the pattern varied for the different age groups, notably that pedestrians aged 15-44 years were more likely to be injured on weekend days than weekdays.

Overall, the highest proportion of hospital-treated pedestrian injury cases occurred in winter (28%, the season with the highest rainfall in Victoria) and the lowest in summer (21%). Small et al. (2006) studied 180 adult pedestrian injury hospital admissions to one inner Sydney hospital over a two-year period. A higher proportion of admissions occurred in Autumn (33%), the season with the highest average rainfall in Sydney, than in Spring (25%); Winter (23%) and Summer (19%).

Crash location

There is no information on hospital injury surveillance datasets abtout the specific location of the pedestrian crash. Research shows that roadway characteristics are closely associated with both the frequency and severity of pedestrian injury crashes (Lee and Abdel-Aty, 2005).

The posted speed of the road is an important determinant of the severity of the injury sustained by pedestrians. Anderson et al. (1997) studied 176 fatal pedestrian crashes in Adelaide and found that even small reductions in the urban area speed limit noticeably reduced the pedestrian fatality rate. As already cited, similar results were obtained in Victoria when the default speed limit on urban roads reduced from 60km/hr to 50km/hr (Hoareau et al., 2006). Several overseas mathematical modeling studies have indicated that lower speed limits are associated with less severe pedestrian crashes (Garder, 2004; Chalabi et al. 2008; Eluru et al. 2008). Corben (2007) recommends that vehicle speeds should not exceed 30km/hr in urban areas where pedestrian crash risk is significant and separation of pedestrian and vehicles impractical, as up to this speed the risk of serious trauma to pedestrians is low.

Research results are conflicting on whether pedestrian crashes at signalised intersections result in more severe injuries than mid-block crashes. Some studies have found that signalization reduces the risk of pedestrian death and severe injury (Sandt & Zegeer 2006; Kim et al. 2008), while others have found that the risk of mortality and injury severity was higher at signalised intersection crashes than crashes elsewhere (Sze & Wong, 2007; Eluru et al., 2008).

Two studies have reported that road hierarchy affects the level of injury severity sustained by pedestrians (Pitt et al. 1990; Rifaat & Chin 2007). The greater the number of lanes and road width appear to be risk factors for pedestrian crashes (Zegeer et al., 2001; Zajac & Ivan, 2003; and Sze & Wong, 2007). There also appears to be a relationship between the design of public transport stops and the occurrence and severity of pedestrian crashes (Unger et al., 2002; Hedelin et al.,1996).

Crash factors

The role of impact speed, a key factor in crash outcome, has already been discussed. Kim et al. (2008) found that pedestrians hit by turning or backing vehicles were more severely injured, as did Abdel-Aty & Keller (2005). However, Roudsari et al. (2006) found that the association no longer existed when analysis was adjusted for impact speed. Research by Pitt (1990) indicated that any attempt by the driver to avoid hitting the pedestrian causes less severe outcomes.

Pedestrian movement also influences risk of serious injury. A study by Clifton (2009) found that crossing against traffic signals or not on a crosswalk worsens the injury outcome. Similarly, Sze & Wong (2007) found that pedestrians involved in a crash at a crossing or within 15 metres of a crossing are at a higher risk of death or severe injury. However, Zegeer & Stewart (2001) reported that pedestrian crashes at marked crosswalks are more severe than those occurring at unmarked ones because drivers and pedestrians are both confused about right-of-way.

Combined risk factors

Some studies have found that combinations or interactions of risk factors, for example age, gender and alcohol misuse, greatly increase injury risk. For example, an Australian study of adult pedestrian crash victims identified three distinct high risk groups: the sober elderly, intoxicated young or middle-aged males, and male and female teenagers (Holubowycz, 1995).

Fontaine and Gourlet (1997) studied pedestrian fatal crashes in France between 1990 and 1991 and found that the elderly crossing urban roads, children playing or running in urban areas during the day time, drunken people who were walking on rural roads, and pedestrians in secondary crashes or in changing transport mode crashes had higher risks of being killed.

Evidence-based pedestrian safety countermeasures

It is beyond the scope of this report to undertake a detailed review of the evidence base for the effectiveness of all the potential countermeasures to pedestrian







PROMISING REVIEW: SUMMARY OF RESULTS

Category	Most promising technical safety measures
(1) Measures that lower motor vehicle speeds to reduce stopping distances/ soften impacts (includes area wide speed reduction schemes, roundabouts, speed humps etc.)	1. Round top hump speed cushion 2. Side protection screen on trucks and other vehicles
(2) Measures that reduce conflict between pedestrian flows and motorised traffic by segregation (e.g. traffic restrictions, ring road/bypass, street closures, location of parking at the border of a protected area)	3. Protection of sidewalk against unwanted usage, i.e. uncontrolled parking, use of pavement by vehicles (cars, bikes), to conserve the space for pedestrians
(3) Measures that facilitate and protect pedestrians crossing a stream of vehicular traffic (includes zebra, "unofficial" and 'smart" crossings)	4. Zebra crossings 5. Yellow flashing light at crossings 6. Refuge 7. Median opening 8. Strip/short section of median 9. Diagonal crossing
(4) Measures that improve visibility of pedestrians to drivers and vehicles to pedestrians (includes lighting, removal of obstacles, daytime running lights on vehicle)	10. Better lateral visibility for trucks and other vehicles
(5) Measures that improve the readability of the road environment for all road users (legibility of signs and markings, colouring of road surface /markings at zebra crossings)	11. Legibility and messages of signs/markings
(6) Improved vehicle design to prevent or reduce the severity of pedestrian accidents (e.g., speed limiters on larger vehicles,)	12. Side protection screen on trucks and other vehicles
(7) Measures that solve problems of vulnerable pedestrians i.e. children, older people and people with disabilities (crossing patrols, ramps for wheelchairs, tactile indicators etc.)	13. Curb cut 14. Anti-slip walking path surface 15. Ice tracks for pedestrians 16. Ramp for wheelchairs/ mobility handicapped 17. Adjustment of signal timing assuming lower walking speeds 18. Colour contrast for the ill-sighted 19. Tactile indicator for the blind/ill-sighted 20. Signal push button at convenient height for wheelchairs
(8) Improve road user behaviour through education, enforcement or social measures (education common only for children and education of drivers and enforcement is usually considered inadequate)	Not applicable (non-technical)

injury; instead we present a summary of the findings from good quality published literature reviews. They include a general review that assessed the pedestrian safety measures implemented in 6 European countries and identified a set of the most promising technical measures (Yannis et al., 2007) and 6 more specific reviews of traffic engineering countermeasures, area-wide traffic calming measures, education interventions and strategies to address alcohol intoxication in pedestrians.

(1) General review

Although not a conventional literature review, in this ambitious project —PROMISING: Promotion of mobility and safety for vulnerable road users— sponsored by the European Commission, researchers from a number of research centres and universities assessed the broad range of tested and non-tested pedestrian safety measures implemented in six European countries to identify the most promising measures for solving identified pedestrian safety problems (PROMISING 2001; Yannis et al., 2007).

Eight categories of measures were assessed (see table left), encompassing 100 specific technical and non-technical pedestrian safety measures. The final stage of the review concentrated on identifying the most promising technical safety measures using two criteria: (1) non-restrictive from the pedestrians' viewpoint; and (2) of high, or at least moderate, effectiveness coupled with low cost. The 20 technical measures recommended for more widespread implementation are shown in the table (left).

The review authors commented that pedestrian safety measures are best implemented holistically using a co-ordinated approach rather than in a piecemeal fashion, that very often a combination of measures is required to bring about the desired solution and that pedestrian safety would only be improved if tradeoffs in terms of impacts on travel conditions and mobility of all traffic participants were accepted.







(2) Specific reviews

(a) Engineering measures (modifications to the built environment)

Retting et al. (2003) reviewed the research literature on traffic engineering modifications to the built environment that can reduce the risk of vehicle-pedestrian crashes or the severity of pedestrian injuries. These generally fall into three categories: speed reduction, separation of pedestrians from vehicles and pedestrian visibility and conspicuity enhancement measures. Well-designed controlled before-after, case-control and cross-sectional evaluation studies were included in the review. For some promising interventions, however, only evaluations with somewhat less reliable methodologies were available.

Five measures were found to be highly effective:

- modern roundabouts in place of conventional intersections especially single lane roundabouts (potential 75% reduction in crashes);
- exclusive pedestrian signal phasings at intersections with traffic signals which stop all vehicle traffic for part or all of the pedestrian crossing signal (potential 24-50% reduction in crashes);
- sidewalks (potential 50% reduction in crash risk);
- pedestrian refuge islands located in the medians of two-way streets and multilane roads (potential 40-65% reduction in crash risk); and
- increased intensity of roadway lighting (potential 60% decrease in night-time crashes).

Three measures were assessed as promising, based on somewhat limited evidence:

- advance stop lines (substantial increase in distance of stopped vehicles from crosswalks);
- in-pavement flashing lights (decreased speeds near crosswalks, increased proportion of drivers yielding to pedestrians); and
- automatic pedestrian detection at walk signals (substantial decreases in the proportion of pedestrians crossing on 'don't walk' signal and pedestrian-vehicle conflicts).

The authors stated that vehicle speed management appears to be the most promising injury prevention intervention in residential settings with large numbers of children, as slower speeds give drivers more time to take evasive action if children dart out on the road or make errors of judgment when road crossing and can lessen injury severity when crashes occur.

(b) Area wide traffic calming

Area wide traffic calming aims to discourage 'through' traffic on residential roads, usually in identified 'hot spots' near the centre of cities and towns, to prevent traffic related injuries. Calming strategies include measures to slow down and/or redistribute traffic (for example reduced speed limit zones, speed humps, roundabouts, road narrowing, blocking off roads, one-way streets), increase visual and audible cues (such as road surface treatments and changes to road lighting) and changes to the road environment (for example increased vegetation along road and street furniture).

This Cochrane systematic review[1] by Bunn et al. (2009) was restricted to high quality evidence of effectiveness i.e. findings from randomised controlled trials (RCT) and controlled before-after studies. After an exhaustive search the authors identified 22 controlled before-after studies that met their inclusion criteria. No RCTs were found. The review was last updated in December 2007.

Of the 22 eligible evaluation studies, seven were conducted in Germany, seven in the UK, two in Australia (in Sydney), two in the Netherlands, two in Denmark, one in Japan and one in Spain. In all studies, a combination of traffic calming measures was implemented in predominantly residential areas lying close to the CBD of a large town or city. The studies used different outcome measures (road traffic deaths, road traffic injuries, road crashes and pedestrian-motor vehicle crashes). Results of the studies that reported the same outcome measure/s were expressed as rate ratios, comparing the incidence of the events of interest in the intervention area to that predicted from the rates in the control area, and pooled.

Meta-analyses (combining data from studies using the same outcome measure) showed:

- a non-significant 21% decrease in the incidence of road traffic crashes (Pooled rate ratio 0.79, 95% CI 0.23-2.68);
- a small but significant 15% decrease in the incidence in road crashes resulting in injury (Pooled RR 0.85, 95% CI 0.75-0.96);
- a non-significant 11% decrease in the number of road crashes (RR 0.89, 95% CI0.76-1.05); and
- no effect on the number of pedestrian-motor vehicle crashes (Pooled RR 1.01, 95% CI 0.88-1.16).

The authors concluded that area traffic calming in towns and cities may be a promising intervention for reducing the number of traffic injuries and deaths but more rigorous research is needed to confirm the effectiveness of this strategy. They also point out that the lack of evidence to support the effectiveness of traffic calming schemes on pedestrian-vehicle crashes does not exclude the possibility that calming may reduce the likelihood of injury in the event of a collision, due to the decrease in impact forces at lower vehicle speeds.

(c) Interventions to increase pedestrian and cyclist visibility (conspicuity)

A similar methodology to the review described above was applied by Kwan & Mapsone (2009) in their Cochrane review of interventions for increasing pedestrian and cycling visibility for the prevention of death and injuries. The failure of drivers to see the pedestrian or cyclist is a major

[1] Cochrane Reviews are systematic reviews of primary research in human health care and health policy. They investigate the effects of interventions for prevention, treatment and rehabilitation. Each systematic review addresses a clearly formulated question. All the existing primary research on a topic that meets certain criteria is searched for and collated, and then assessed using stringent guidelines, to establish whether or not there is conclusive evidence about a specific intervention. The reviews are updated regularly, ensuring that decisions about interventions can be based on the most up-to-date and reliable evidence. www.cochrane.org/cochrane-reviews







cause of pedestrian- and cyclist-vehicle crashes, especially at night. Visibility (conspicuity) aids include reflective garments/tags/accessories (for pedestrians and bicyclists) and reflectors/flashing lights (for bicyclists). Bio-motion markings are retro-reflectors on major joints that make pedestrians and cyclists conspicuous by highlighting the movement or form of the pedestrian/cyclist.

The literature search (last updated in May 2009) found no trials that measured the effect of visibility aids on the occurrence of pedestrian and cyclist-motor collisions and injuries, but identified 42 eligible RCTs that assessed the effect of visibility aids on drivers' responses. The trials were so diverse that no attempt was made to pool results.

On the weight of available evidence, the authors concluded that:

- fluorescent materials in yellow, red and orange improve daytime driver detection; and
- lamps, flashing lights and retroreflective materials in red and yellow, particularly bio-motion markings improve nighttime driver detection.

While research showed that visibility measures help drivers see pedestrians and cyclists, it is not known whether improved detection translates to injury prevention. A large and complex community trial would be needed to answer this question. As for all behaviour change interventions, a major challenge is getting a consistently high level of compliance in the target group/s. This requires regular re-enforcement of the message through awareness raising strategies and education.

(d) Safety education of pedestrians

Duperrex and colleagues (2009) have undertaken a Cochrane review of the effectiveness of pedestrian safety education for injury prevention, first published in 2002. Their review is restricted to RCTs and covers all ages. Most database searching was done in 1999 and the review content was assessed by the authors as up-to-date in February 2005.

The authors screened 14,000 published and unpublished studies and identified 15 RCTs that met their inclusion criteria but further examination showed that the methodological quality of included trials was generally poor. Study participants were children in 14 trials and institutionalised adults in one. The trials were conducted in Scotland, England, Australia (Melbourne), Germany, US, Canada, and Japan. None assessed the effect of education on the occurrence of injury, but six assessed the effect on observed behaviour. The studies were so diverse that no attempt was made to pool results.

The authors concluded that pedestrian safety education can improve children's road safety knowledge and can change observed road crossing behaviour but that it was difficult to predict whether these effects would reduce child pedestrian injury. The research indicated that regular booster education sessions would be needed as there was clear evidence that children's safety knowledge decayed over time.

Hotz et al. (2009) focused their recent non-systematic review on interventions aimed at reducing child pedestrian injury. The authors summarised the learning since the 1970s from child pedestrian risk factor studies and evaluations of larger scale interventions undertaken in developed countries such as United Kingdom, Australia and the United States. They concluded that the results from child pedestrian education programs were "generally disappointing" and that expert opinion was in agreement that a multifaceted approach to child pedestrian injury prevention (that combined community awareness raising, education of drivers and pedestrians, road crossing skills training of children, safety regulation and enforcement and environment modification) had the most potential for success.

The authors then reported the progress of The Walksafe Program, a multifaceted elementary school education program that they helped devise for implementation in Florida in the US. The demonstration project was initiated in elementary schools (Kindergarten to Grade 5) in Miami-Dade County, the largest county in Florida, in 2003 and the program was subsequently expanded to involve all school systems throughout Florida.

The multiagency program focuses on five Es: education – a 3-day standardised curriculum taught in the classroom combined with outside simulation; engineering modifications around schools and identified local pedestrian-vehicle crash 'hot spots' delivered by government Public Works Department; enforcement of pedestrian safety laws by city and local government and police; evaluation in the form of various research assessments using validated survey tools; and encouragement primarily comprised of supportive Parent-Teacher Association and community interactions (www.walksafe.us). Preliminary results appear promising with a significant decrease in child pedestrian injuries in Dade County noted in the post-implementation period and significant gains and retention of student pedestrian safety knowledge. Behavioural changes from the knowledge gains have yet to be determined. A prospective cohort study evaluating the usefulness of the WalkSafe program is underway in New Haven, Connecticut (Violano et al., 2009).

As mentioned by the review authors, virtual reality training (VRT) is a promising recent intervention in the field of child pedestrian safety training. Investigators from the UK, US and Australia have showed that VRT improves roadside crossing judgments in groups of child pedestrians (Thomson et al., 2005; Oxley et al., 2008). Oxley et







al (2008) conducted a RCT in Melbourne to evaluate the effectiveness of a targeted and practical training program for primary school children using a simulated road environment. Significant reductions in proportion of critically incorrect road crossing responses were found immediately after training (56%) and one month post-training (47%) by the case group compared with pre-training responses, and relative to any changes in responses of the control group. The beneficial effects were greater for younger children, females, children with less well-developed perceptual, attentional and cognitive skills, and those with little traffic exposure.

Schwebel & McClure (2010) have a laboratory-based RCT underway to test the efficacy of VRT in which they are measuring the performance of three safe crossing behaviours in an intervention group of 60 children aged 7-8 years receiving interactive immersive VRT and comparing their performance to that of groups receiving video and computer training, individual roadside training at streetside locations and no-contact (control group).

(e) Intoxicated pedestrians

Hutchinson et al. (2010) recently reviewed the possible countermeasures to the problem of pedestrian crashes involving intoxicated pedestrians. They divided intervention into three categories and assessed the evidence base for the range of possible countermeasures within each category.

(1) Measures to prevent intoxication: the prevention and treatment of alcohol dependency; policy (pricing), regulatory (for example, restriction of trading hours of licensed premises and restriction on price discounting) and other measures (for example licensee codes of conduct) combined with enforcement to restrict alcohol availability; targeting of licensed premises to both train bar staff better and enforce responsible service of alcohol; public health campaigns

(2) Measures to minimise pedestrian activity by the intoxicated: provision of alternative transport modes from licensed premises; policing of public drunkenness and intervention by police or alternative agency; making it an offence to be walking in or near traffic with a "too-high" BAC.

(3) Measures to minimise the risk of injury: public health awareness campaign targeting drivers; identifying 'hot spots' for drunken pedestrian crashes and utilisation of site data to devise appropriate injury prevention measures; and encouraging pedestrians to wear highly conspicuous clothing at night.

The authors conclude that the literature is pessimistic on the effectiveness of known countermeasures to the intoxicated pedestrian problem and indicates that the effect of countermeasures on the total number of crashes involving drunk pedestrians would probably be low. They viewed a statutory limit on blood alcohol level in public places, accompanied by enforcement, as the most promising of potential countermeasures.

Conclusion

Over the decade 1999-2008 traffic-related hospital-treated pedestrian injury rates decreased significantly, perhaps when there may have been some increase in walking as a form of transport in inner urban areas which are among the highest risk locations for pedestrian injury. Available evidence indicates that the downturn in injury was largely due to the reduction of the default vehicle speed limit to 50km/hr in 2001 (with the effect observed between 2002 and 2005) along with strengthened enforcement of traffic speed limits, but other interventions may have played a small part.

In the last three years of the decade progress on reducing pedestrian injury has stalled, which suggests that it is time to re-invigorate commitment to preventive action. Study results indicate that some priority should be given to research and interventions that aim to reduce injury in males aged 15-29, older people, intoxicated pedestrians, people born in mainly non-English speaking countries especially those that have the convention of driving on the right, children (because of their special vulnerability) and the LGAs with comparatively high pedestrian admission rates.

Recommendations

- Integrate pedestrian crash and injury monitoring systems into current traffic monitoring systems to provide data to underpin safety initiatives in high-risk areas.
- Increase the routine testing for alcohol of pedestrians presenting to hospital emergency departments and establish a system to facilitate the entry of blood test results on hospital injury surveillance datasets for research, prevention and evaluation purposes.
- Conduct a study to determine the crash and injury risk factors for pedestrians aged 15 to 29 years-old.
- Implement pedestrian safety holistically using a co-ordinated approach as very often a combination of measures and the co-operation of different levels of government are required to bring about the desired solution.
- Consider the evidence base for safety measures before implementation and fully evaluate any new safety measures or packages of measures, integrating the evaluation at the intervention design phase.
- In recognition of the major reductions in pedestrian crash and injury risk that result from lower travel and impact speeds, introduce lower speed limits in areas of high pedestrian activity, where effective separation between pedestrians and vehicles is impractical. Progressively support lower limits with infrastructure improvements that make lower speeds a natural choice for drivers and riders.
- When making design and operational decisions regarding roadways and the pedestrian network, consider the heightened injury risks and special needs of the most vulnerable of pedestrians - older people, people with disabilities, children and people born in non-English speaking countries and countries where convetnion is to drive on the right side of the road.







- Develop interventions to educate/alert/ reinforce pedestrian and drivers on right-of-way rules on various pedestrian crossing types.
- Develop messages that explicitly suggest techniques for pedestrians avoiding mobile phone use when crossing roads. The new regulations controlling mobile phone use by drivers should be evaluated for effectiveness as evidence indicates that any use degrades driving performance.

References

Abdel-Aty M, Keller J. Exploring the overall and specific crash severity levels at signalized intersections. Accid Anal Prev. 2005; 37(3): 417-425.

Al-Ghamdi AS. Pedestrian-vehicle crashes and analytical techniques for stratified contingency tables. Accid Anal Prev. 2002; 34(2): 205-214.

Anderson RW, McLean AJ, Farmer MJ, Lee BH, Brooks CG. Vehicle travel speeds and the incidence of fatal pedestrian crashes. Accid Anal Prev. 1997; 29(5): 667-674.

Australian Bureau of Statistics. 9309.0 – Motor Vehicle Cencus, Australia, 31 Mar 2009.

Australian Transport Safety Bureau. Road fatalites among older pedestrians. ATSB Monograph 13, Canberra 2002 http:/www.infrastructure.gov.au/roads/safety/publications/2002/Ped_Age_2.aspx. Dowloaded 14/04/2010.

Australian Transport Safety Bureau. Male pedestrian fatalities. ATSB Monograph 14, Canberra. 2003. http:/www.infrastructure.gov.au/roads/safety/publications/2003/Ped_Male_1.aspx. Dowloaded 14/04/2010.

Austroads. Pedestrian and cycling safety – pedestrian crashes at pedestrian facilities. Report No. AP-R156, Austroads, Sydney, 2000.

Bartley Consulting Pty Ltd. Walking and cycling census analysis. Consultancy report prepared for the Victorian Department of Transport, Walking and Cycling Branch. September 2008.

Beck LF, Paulozzi LJ, Davidson SC. Pedestrian fatalities, Atlanta Metropolitan Statistical Area and United States, 2000-2004. J Safety Res. 2007; 38(6): 613-616.

Bradbury A. Pattern and severity of injury sustained by pedestrians in road traffic accidents with particular reference to the effect of alcohol. Injury.1991; 22(2): 132-134.

Bungum TJ, Day C, Henry LJ. The association of distraction and caution displayed by pedestrians at a lighted crosswalk. J. Community Health. 2005; 30(4): 269-79.

Bunn F, Frost C, Ker K, et al. Area-wide traffic calming for preventing traffic related injuries. Cochrane Database of Systematic Reviews 2003, Issue 1. Art. No.: CD003110.

Cairney P, Stephenson W, Macaulay J. Preventing crashes involving intoxicated pedestrians. Stage 2 – An analysis of Australian coronial records, 1999-2001. In: Austroads Research Report AP-R260/04 pp. 63-119. Sydney: Austroads.

Chalabi Z, Roberts I, Edwards P, et al.Traffic and the risk of vehicle-related pedestrian injury: a decision analytic support tool. Inj Prev. 2008; 14(3): 196-201.

Chang L, Wang H. Analysis of traffic injury severity: An application of non-parametric classification tree techniques. Accid Anal Prev. 2006; 38(5): 1019-1027.

Charlton J, Oxley J, Scully J, et al. Self-regulatory driving practices of older drivers in the ACT and NSW. Monash University Accident Research Centre; October 2006. Report No.: 254. www.monash.edu.au/muarc/reports/muarc254.pdf

Chisholm SL, Caird JK, Lockhart J. The effects of practice with MP3 players on driving performance. Accid Anal Prev. 2008; 40(2): 704-713.

Clapperton A, Cassell E. The impact of area socioeconomic inequity on serious injury in Victoria. Hazard Edition No 70 Summer 2009/10. Victorian Injury Surveillance Unit. Melbourne.

Clifton K, Burnier C, Akar G. Severity of injury resulting from pedestrian-vehicle crashes: What can we learn from examining the built environment? Transp. Res.: Part D: Transport Environ. 2009; 14(6): 425-436.

Connelly ML, Conaglen HM, Parsonson BS, et al. Child pedestrian's crossing gap thresholds. Accid Anal Prev. 1998; 30(4): 443-453.

Connelly LB, Supangan R. The economic costs of road traffic crashes: Australia, states and territories. Accid Anal Prev. 2006; 38(6): 1087-1093.

Corben B, D'Elia A, Healy DJ. Estimating pedestrian fatal crash risk. In: Proceedings, 2006 Australasian Road Safety Research, Policing and Education Conference. October 2006, Gold Coast, Australia.

Corben B.F. Achieving safe traffic environments for pedestrians. Melbourne, Victoria: Monash University, 2007. Thesis.

Corben BF, Diamantopoulou K, Mullan N, Mainka B. Environmental countermeasures for alcohol-related pedestrian crashes. Monash University Accident Research Centre; 1996, Report No. 101.

Delaney A, Newstead S, Corben B. Outcome evaluation of the effectiveness of the Safe Routes to Schools program. Monash University Accident Research Centre; 2004, Report No. 225.

Delaney A, Diamantopoulou K, Cameron M. Strategic principles of drink-driving enforcement. Monash University Accident Research Centre; July 2006. Report No.: 249. www.monash.edu.au/muarc/reports/muarc249.pdf

Demetriades D, Murray J, Martin M, et al. Pedestrians injured by automobiles: relationship of age to injury type and severity. J Am Coll Surg. 2004; 199(3): 382-387.

Desapriya E, Subzwari S, Sasges D, et al. Do light truck vehicles (LTV) impose greater risk of pedestrian injury than passenger cars? A meta-analysis and systematic review. Traffic Inj Prev. 2010; 11(1): 48-56.

Dobson A, Smith N, McFadden M, et al. In Australia are people born in other countries at higher risk of road trauma than locally born people? Accid Anal Prev. 2004; 36(3): 375-381.

Drews FA, Yazdani H, Godfrey CN et al. Text messaging during simulated driving. Hum Factors. 2009; 51(5): 762-70

Duperrex OJM, Roberts IG, BunnF. Safety education of pedestrians for injury prevention. Cochrane Database of Systematic Reviews 2002, Issue 2. Art. No.: CD001531.

Durkin MS, Davidson LL, Kuhn L, O'Connor P, Barlow B. Low-income neighborhoods and the risk of severe pediatric injury: a small-area analysis in Northern Manhattan. Am J Public Health. 1994; 84(4): 587-592.

Eluru N, Bhat CR, Hensher DA. A mixed generalized ordered response model for examining pedestrian and bicyclist injury severity level in traffic crashes. Accid Anal Prev. 2008; 40(3): 1033-1054.

Federal Office of Road Safety (FORS). Pedestrian fatalities in Australia. Monograph 7, Federal Office of Road Safety, Canberra, Australia, 1996. http://www.rsconference.com/pdf/RS07037.pdf?check=1

Fontaine H, Gourlet Y. Fatal pedestrian accidents in France: A typological analysis. Accid Anal Prev. 1997; 29(3): 303-312.

Gårder PE. The impact of speed and other variables on pedestrian safety in Maine. Accid Anal Prev. 2004; 36(4): 533-542.

Giles-Corti B, Kelty SF, Zubrick et al. Encouraging walking for transport and physical activity in children and adolescents: how important is the built environment? Sports Med. 2009; 39(12): 995-1009.

Graham DJ, Stephens DA. Decomposing the impact of deprivation on child pedestrian casualties in England. Accid Anal Prev. 2008; 40(4): 1351-1364.

Harkey D, Zegeer C. PEDSAFE: Pedestrian safety guide and countermeasure selection system. Washington, D.C., FHWA, 2004.

Harrison JE & Berry JG. Injury of Aboriginal and Torres Strait Islander people due to transport, 2001–02 to 2005–06. Injury research and statistics series number 46. Cat. no. INJCAT 120. Adelaide: AIHW, 2008

Harruff RC, Avery A, Alter-Pandya AS. Analysis of circumstances and injuries in 217 pedestrian traffic fatalities. Accid Anal Prev. 1998; 30(1): 11-20.

Hatfield J, Murphy S. The effects of mobile phone use on pedestrian crossing behaviour at signalized and unsignalized intersections. Accid Anal Prev. 2007;39(1):197-205.

Hatfield J, Fernandes R, Soames Job RF, Smith K. Misunderstanding of right-of-way rules at various pedestrian crossing types: observational study and survey. Accid Anal Prev. 2007; 39(4): 833-42.

Haworth N, Johnson IR, Vulcan AP. Mid-term review of arrive alive!, Victoria's road safety strategy 2002-2007, Part 2: Comparison of actual and predicted road trauma reduction of each initiative, Monash University Accident Research Centre, contract report prepared for VicRoads, Victoria, Australia, 2005.

Hedelin A, Björnstig U, Brismar B. Trams--a risk factor for pedestrians. Accid Anal Prev. 1996; 28(6): 733-738.

Hewson P. Deprived children or deprived neighbourhoods? A public health approach to the investigation of links between deprivation and injury risk with specific reference to road safety in Devn County, UK. BMC Public Health. 2004; May 10;4:15







Hippisley-Cox J, Groom L, Kendrick D, Coupland C, Webber E, Savelyich B. Cross sectional survey of socioeconomic variations in severity and mechanism of childhood injuries in Trent 1992-7. BMJ. 2002; 324(7346): 1132.

Holubowycz OT. Age, sex, and blood alcohol concentration of killed and injured pedestrians. Accid Anal Prev. 1995; 27(3): 417-422.

Hoareau E, Newstead S, Cameron M. An evaluation of the default 50 km/h speed limit in Victoria. Melbourne: Monash University Accident Research Centre; November 2006. Report No.: 261. www.monash.edu.au/muarc/reports/muarc261.pdf

Hosking SG, Young KL, Regan MA. The effects of text messaging on young drivers. Hum Factors. 2009;51(4):582-92.

Hotz G, Kennedy A, Lufti K et al. Preventing pediatric pedestrian injuries. J Trauma. 2009;66:1492-1499.

Hutchinson TP, Kloeden CN, Lindsay VL. Countermeasures to the problem of accidents to intoxicated pedestrians. J Forensic Leg Med. 2010; 17(3):115-9.

Kim JK, Ulfarsson GF, Shankar VN, et al. Age and pedestrian injury severity in motor-vehicle crashes: A heteroskedastic logit analysis. Accid Anal Prev. 2008; 40(5): 1695-1702.

King MJ, Soole D, Ghafourian A. Illegal pedestrian crossing at signalised intersections: incidence and relative risk. Accid Anal Prev. 2009;41(3):485-90.

Kwan I, Mapstone J. Interventions for increasing pedestrian and cyclist visibility for the prevention of death and injuries. Cochrane Database of Systematic Reviews 2006, Issue 4. Art. No.: CD003438.

LaScala EA, Gerber D, Gruenewald PJ. Demographic and environmental correlates of pedestrian injury collisions: a spatial analysis. Accid Anal Prev. 2000; 32(5): 651-658.

Lee C, Abdel-Aty M. Comprehensive analysis of vehicle-pedestrian crashes at intersections in Florida. Accid Anal Prev. 2005; 37(4): 775-786.

Loo BP, Tsui KL. Pedestrian injuries in an ageing society: insights from hospital trauma registry. J Trauma. 2009; 66(4): 1196-201.

Lorenc T, Brunton G, Oliver S et al. Attitudes to walking and cycling among children, young people and parents: a systematic review. J. Epidemiol Community Health 2008; 62: 852-857.

Lyons RA, Jones SJ, Deacon T, Heaven M. Socioeconomic variation in injury in children and older people: a population based study. Inj Prev. 2003; 9: 33-37.

Mabunda MM, Swart LA, Seedat M. Magnitude and categories of pedestrian fatalities in South Africa. Accid Anal Prev. 2008; 40(2): 586-593.

Martin, AJ, Hand EB, Trace F, et al. Pedestrian fatalities and injuries involving Irish older people. Gerontology. 2010; 56(3): 266-71.

McCartt AT, Hellinga LA, Bratiman KA. Cell phones and driving: review of research. Traffic Inj Prev. 2006; 7(2): 89-106.

McEvoy SP, Stevenson MR, McCartt AT, et al. Role of phones in motor vehicle crashes resulting in hospital attendance: a case-crossover study. BMJ. 2005; 331(7514): 428.

McKenzie K, Harrison JE, McClure RJ. Identification of alcohol involvement in injury-related hospitalisations using routine data compared to medical record review. Aust NZ J Public Health. 2010; 34: 146-152

Nasar J, Hecht P, Wener R. Mobile telephones, distracted attention, and pedestrian safety. Accid Anal Prev. 2008;40(1):69-75.

Olson, R.L., Hanowski, R.J., Hickman, J.S., & Bocanegra, J. Driver Distraction in Commercial Vehicle Operations. FMCSA RRR 09 042. Washington, DC: Federal Motor Carrier Safety Administration. 2009, September.

Öström M; Eriksson A. Pedestrian fatalities and alcohol. Accid Anal Prev. 2001; 33(2): 173-180.

Oxley J, Fildes B, Ihsen E et al. Differences in traffic judgments between young and old adult pedestrians. Accid anal Prev. 1997; 29(6): 962-971

Oxley JA, Ihsen E, Fildes BN et al. Crossing roads safely: an experimental study of age differences in gap selection by pedestrians. Accid Anal Prev. 2005 Sep; 37(5):962-71.

Oxley J, Lenne M, Corben B. The effect of alcohol impairment on road crossing behaviour. Transportation Research Part F: Traffic Psychology and Behaviour 2006; 9(4): 258-268.

Oxley JA, Congiu M, Whelan M, D'Elia A, Charlton J. The impacts of functional performance, behaviour and traffic exposure on road-crossing judgements of young children. Annu Proc Assoc Adv Automot Med. 2007; 51: 81-96.

Oxley J, Congiu M, Whelan M, D'Elio A, Charlton J. Teaching young children to cross roads safely. Annu Proc Assoc Adv Automot Med. 2008; 52: 215-23.

Paulozzi LJ. United States pedestrian fatality rates by vehicle type. Inj Prev. 2005; 11(4): 232-236.

Peng RY, Bongard FS. Pedestrian versus motor vehicle accidents: an analysis of 5,000 patients. J Am Coll Surg. 1999; 189(4): 343-348.

Pitt R, Guyer B, Hsieh CC, Malek M. The severity of pedestrian injuries in children: An analysis of the Pedestrian Injury Causation Study. Accid Anal Prev. 1990; 22(6): 549-559.

Plurad D, Demetriades D, Gruzinski G, et al. Pedestrian injuries: the association of alcohol consumption with the type and severity of injuries and outcomes. J Am Coll Surg. 2006; 202(6): 919-927.

Poulos RG, Hayen A, Finch C, Zwi A. Area socioeconomic status and childhood injury morbidity in NSW. Inj Prev. 2007; 13: 322-327.

Preusser DF, Well JK, Williams AF et al. Pedestrian crashes in Washington, DC and Baltimore. Accid Anal Prev. 2002; 34: 703-710.

PROMISING Measures for pedestrian safety and mobility problems. Final report of workpackage 1. NTUA National Technical University of Athens, Greece. 2001. http://ec.europa.eu/transport/roadsafety_library/publications/promising_deliverable_1.pdf

Redelmeier DA, Tibshirani RJ. Association between cellular-telephone calls and motor vehicle collisions. N Engl J Med. 1997; 336(7): 453-458.

Retting RA, Ferguson SA, McCartt AT. A review of evidence-based traffic engineering measures designed to reduce pedestrian-motor vehicle crashes. Am J Public Health. 2003; 93(9): 1456-1463.

Rifaat SM, Chin HC. Accident severity analysis using ordered probit model. J Adv Transport. 2007; 41(1): 91-114.

Roudsari B, Mock C, Kaufman R.An evaluation of the association between vehicle type and the source and severity of pedestrian injuries. Traffic Inj Prev. 2005; 6(2): 185-192.

Roudsari B, Kaufman R, Koepsell T. Turning at intersections and pedestrian injuries. Traffic Inj Prev. 2006; 7(3): 283-289.

Ryb GE, Dischinger PC, Kufera JA, et al. Social, behavioral and driving characteristics of injured pedestrians: a comparison with other unintentional trauma patients. Accid Anal Prev. 2007; 39(2): 313-318.

Sandt L, Zegeer C. Characteristics Related to Midblock Pedestrian—Vehicle Crashes and Potential Treatments. Transport Res Rec. 2006; 1982(1): 113-121.

Schwebel DC, McClure LA. Using virtual reality to train children in safe street crossing skills. Inj Prev 2010; 16(1); e1-5.

Shults RA, Nichols JL, Dinh-Zarr TB, et al. Effectiveness of primary enforcement safety belt laws and enhanced enforcement of safety belt laws: A summary of the Guide to Community Preventive Services systematic reviews. J Safety Research 2004; 34: 189-196.

Small TJ, Sheedy JM, Grabs AJ. Cost, demographics and injury profile of adult pedestrian trauma in inner Sydney. ANZ J. Surg. 2006; 76: 43-47.

Starnes MJ, Hadjizacharia P, Chan LS, et al. Automobile versus pedestrian injuries: does gender matter? J Emerg Med. 2008; [Epub ahead of print].

Stavrinos D, Byington KW, Schwebel DC. Effect of cell phone distraction on pediatric pedestrian injury risk. Pediatrics. 2009; 123(2): e179-185.

Sze NN, Wong SC. Diagnostic analysis of the logistic model for pedestrian injury severity in traffic crashes. Accid Anal Prev. 2007; 39(6): 1267-1278.

Telstra. Telstra, police & NRMA Insurance join forces to target mobile phone use on Australian Roads. Telstra News Release, 2003 www.telstra.com.au/newsroom.

Thomson JA, Tolmie AK, Foot HC, Whelan KM, Sarvary P, Morrison S. Influence of virtual reality training on the roadside crossing judgments of child pedestrians. J Exp Psychol Appl. 2005; 11(3): 175-186.

Timperio A, Crawford D, Telford A, Salmon J. Perceptions about the local neighbourhood and walking and cycling among children. Prev Med. 2004; 38(1): 39-47.

Transport Accident Commission. Pedestrian Statistics. www.tacsafety.com.au/jsp/content/NavigationController.do?areaID=12&tierID=1&navID=57348A10&navLink=null&pageID=149. Accessed 17/6/2010.

Unger R, Eder C, Mayr JM, Wernig J. Child pedestrian injuries at tram and bus stops. Injury. 2002; 33(6): 485-488.

VicRoads Safety Rules. Mobile phones and Visual Display Units. http://www.vicroads.vic.gov.au/Home/SafetyAndRules/RoadRules/MobilePhonesandvisualdisplayunits.htm. Accessed 9/6/2010







Box 1 Data sources and case selection

Hospital admissions

Data source: Victorian Admitted Episodes Dataset (VAED)

Hospital admissions for injury and poisoning that contain an external cause code are extracted from the VAED by the Victorian Department of Health (DH) and supplied in unit record format to VISU every six months. The dataset covers admissions to all Victorian public and private hospitals. From July 1998 cases recorded on the VAED are coded to the ICD-10-AM, the WHO International Statistical Classification of Diseases and Related Health Problems, Tenth Revision, Australian Modification. The external causes chapter of the ICD-10-AM describe the causes of injury, poisoning and adverse events (complications of medical and surgical care). Adverse events and sequelae (late effects) of external causes of morbidity and mortality are usually not included in VISU reports.

Case selection:

- Admissions recorded on the VAED that occur between 1 Jan 1999 and 31 Dec 2008 (trends section) and 1 Jan 2006 and 31 Dec 2008 (detailed analysis section)
- Unintentional injury cases with the first external cause code in the range V00-V09 'Pedestrian injured in transport accident' and a fourth character indicating the accident was 'traffic' related. (A traffic accident is any vehicle accident that occurs on the public highway)
- Mode of admission has any value except those indicating that transfer from another hospital has occurred or that the record is a 'statistical separation' – a change of care type within a hospital. The aim of these omissions is to reduce over-counting of cases and to provide an estimated incidence of admission
- Mode of separation has any value except that a person died while in hospital
- Local government area of residence indicated the injured person was Victorian

Emergency Department presentations (non-admissions)

Data source: Victorian Emergency Minimum Dataset (VEMD)

Emergency Department presentations for injury and poisoning are extracted from the VEMD by the Victorian Department of Health (DH) and supplied quarterly in unit record format to VISU. From January 2004, VEMD data are collected by all 38 Victorian public hospitals that provide a 24-hour ED service.

The VEMD contains both admitted and non-admitted cases. Presentations that are treated and discharged from within the ED within 4 hours from the time patient management commences are classified as non-admissions and cases that are treated for 4 hours or more in the ED or a short stay ward attached to the ED or depart from the ED to an inpatient bed or are transferred to another hospital campus are classified as hospital admissions. Admissions for injury and poisoning recorded on the VEMD are not usually included in VISU injury surveillance reports if admissions are also being selected from the VAED because cases would then be over-counted.

Case selection:

- Hospital ED presentations (non-admissions) recorded on the VEMD that occur between 1 Jan 1999 and 31 Dec 2008 (trends section) and 1 Jan 2006 and 31 Dec 2008 (detailed analysis section)
- Initial presentations only
- Cases were selected if the cause of injury was 'pedestrian' AND the intent was 'unintentional' AND the injury occurred on a 'road/street/highway'. All case narratives were then checked for relevance and any that were not considered traffic related were deleted (i.e., falls while walking on footpath, injuring ankle when stepping in a gutter etc)
- Postcode of residence indicated the injured person was Victorian

Violano P, Davis KA, Lane V, Lofthouse R, Carusone C. Establishing an injury prevention program to address pediatric pedestrian collisions. J Trauma Nurs 2009;16(4):216-219

Walkinginfo website (2009). Retrieved 18 September 2009 from: http://www.walkinginfo.org/why/

Yannis, G, Kanellaidis G, Dimitropoulos J, et al. Assessment of pedestrian safety measures in Europe. ITE. 2007; 77(12): 40-48.

Zajac SS, Ivan JN. Factors influencing injury severity of motor vehicle-crossing pedestrian crashes in rural Connecticut. Accid Anal Prev. 2003; 35(3): 369-379.

Zegeer CJ, Stewart RJ, Huang H, et al. Safety effects of marked versus unmarked crosswalks at uncontrolled locations: analysis of pedestrian crashes in 30 cities. Transport Res Rec. 2001; 1773(-1): 56-68.

Box 2 Special analyses: definitions and methods

Estimating rates

Age-adjusted rates were calculated using the direct standardisation method and the Victorian population at June 30 2001 as the standard.

Trend analysis

Trends were determined using a log-linear regression model of the rate data assuming a Poisson distribution of injuries. The statistics relating to the trend curves, slope and intercept, estimated annual percentage change, estimated overall change, 95% confidence intervals around these estimated changes and the p-value, were calculated using the regression model in SAS® 9.1.3 . A trend was considered to be statistically significant if the p-value of the slope of the regression model was less than 0.05.

Alcohol involvement: definition of 'alcohol-related' using ICD-10-AM codes

Cases were identified as involving alcohol if they contained an ICD-10-AM diagnosis or external cause code referring to alcohol, following the approach taken in a recently published Australian study by McKenzie et al (2010)1.

Twenty-four of 28 ICD-10-AM codes that mentioned alcohol in the description were used to identify alcohol involvement:

Diagnosis Codes: E24.4 Alcohol-induced pseudo-Cushing's Syndrome; E52 Niacin deficiency [pellagra]; F10 Mental and behavioural disorders due to use of alcohol; G31.2 Degeneration of nervous system due to alcohol; G62.1Alcoholic polyneuropathy; G72.1 Alcoholic myopathy; 142.6 Alcoholic cardiomyopathy; K29.2 Alcoholic gastritis, K70 Alcoholic liver disease; K85.2 Alcohol induced acute pancreatitis; K86.0 Alcohol induced chronic pancreatitis; O35.4 Maternal care, care for (suspected) damage to fetus from alcohol; R78.0 Finding of alcohol in blood; T51 Toxic effects of alcohol; Z04.0 Blood-alcohol and blood-drug test; Z50.2 Alcohol rehabilitation; Z71.4 Counselling and surveillance of alcohol use disorder; Z72.1 Alcohol use; Z86.41 Personal history of alcohol use disorders.

External cause codes: X45 Accidental poisoning by and exposure to alcohol; X65 Intentional self-poisoning by and exposure to alcohol; Y15 Poisoning by exposure to poisoning undetermined intent; Y90 Evidence of alcohol involvement determined by blood alcohol level; Y91 Evidence of alcohol involvement determined by level of intoxication.

Ethnicity: definition of 'Mainly English speaking countries'

Mainly English speaking countries were defined using the list provided in the Australian Bureau of Statistics (ABS) report Australian Social Trends, 2008 (CAT 41020)2. This list contains countries from which Australia receives, or has received, significant numbers of overseas settlers who are likely to speak English. These countries comprise the United Kingdom, the Republic of Ireland, New Zealand, Canada, South Africa, and the United States of America.

Injury severity: definition of 'serious' injury

To examine the severity of traffic-related pedestrian injury hospital admissions each hospital record was given an International Classification of Disease (ICD)-based Injury Severity Score (ICISS) (Davie et al., 2008)3. The ICISS involves estimating probability of death using the ICD injury diagnosis codes recorded in a person's hospital record. Determining which injuries are 'serious' involves calculating a survival risk ratio (SRR) for each individual injury. An SRR is the proportion of cases with a certain injury diagnosis in which the patient does not die, or in other words, a given SRR represents the likelihood that a patient will survive a particular injury. Each patient's final ICISS is the product of the SRRs associated with all the diagnoses listed on the patient hospital record. An injury is considered serious if the ICISS is less than or equal to 0.941, this is equivalent to a survival probability of 94.1% or worse – meaning the injured person has a probability of death (when admitted) of at least 5.9%.

Costing

The National Hospital Costs Data Collection (NHCDC) is based on the principles of Casemix costing analysis which is a scientific approach to the classification of patient care whereby each hospital admission is assigned an Australian Refined Diagnosis Related Group (AR-DRG)4. AR-DRGs provide a clinically meaningful way of relating the types of patients treated in a hospital to the resources required by the hospital. The NHCDC contains component costs per DRG and enables DRG Cost Weights and average costs for DRGs (National and state/territory specific) for acute in-patients to be produced. The types of component costs included are ward medical, ward nursing, non-clinical salaries, pathology, imaging, allied health, pharmacy, critical care, operating rooms, ED, ward supplies and other overheads, specialist procedure suites, on-costs, prostheses, hotel and depreciation. For this analysis the average Victorian cost per AR-DRG (for the relevant year of admission) was applied to each admission to estimate the hospital costs associated with traffic-related pedestrian injury in Victoria.

1. McKenzie K, Harrison JE, McClure RJ. Identification of alcohol involvement in injury-related hospitalisations using routine data compared to medical record review. Aust NZ J Public Health. 2010; 34: 146-152
2. Australian Bureau of Statistics (ABS). Australian Social Trends, 2008 (CAT 41020).
3. Davie G, Cryer C & Langley J. Improving the predictive ability of the ICD-based Injury Severity Score. Injury Prevention 2008; 14; 250-255.
4. National Hospital Cost Data Collection. Hospital Reference Manual Round 11 (2006-07), September 2007. Australian Government Department of Health and Ageing.







- INDEX -

Subject.. Edition







Acknowledgements

Guest editor

- Dr Bruce Corben, Monash University Accident Research Centre

VISU Staff

Director:	Ms Erin Cassell
Co-ordinator:	Ms Karen Ashby
Research Fellow:	Ms Angela Clapperton
Research Assistants:	Mr Nicholas Reid

Participating hospitals

From October 1995
Austin & Repatriation Medical Centre
Ballarat Base Hospital
The Bendigo Hospital Campus
Box Hill Hospital
Echuca Base Hospital
The Geelong Hospital
Goulburn Valley Base Hospital
Maroondah Hospital
Mildura Base Hospital
The Northern Hospital
Royal Children's Hospital
St Vincents Public Hospital
Wangaratta Base Hospital
Warrnambool & District Base Hospital
Western Hospital - Footscray
Western Hospital - Sunshine
Williamstown Hospital
Wimmera Base Hospital

From November 1995
Dandenong Hospital

From December 1995
Royal Victorian Eye & Ear Hospital
Frankston Hospital

From January 1996
Latrobe Regional Hospital

From July 1996
Alfred Hospital
Monash Medical Centre

From September 1996
Angliss Hospital

From January 1997
Royal Melbourne Hospital

From January 1999
Werribee Mercy Hospital

From December 2000
Rosebud Hospital

From January 2004
Bairnsdale Hospital
Central Gippsland Health Service (Sale)
Hamilton Base Hospital
Royal Women's Hospital
Sandringham & District Hospital
Swan Hill Hospital
West Gippsland Hospital (Warragul)
Wodonga Regional Health Group

From April 2005
Casey Hospital

How to access VISU data:

VISU collects and analyses information on injury problems to underpin the development of prevention strategies and their implementation. VISU analyses are publicly available for teaching, research and prevention purposes. Requests for information should be directed to the VISU Co-ordinator or the Director by contacting them at the VISU office.

Contact VISU at:

MUARC - Accident Research Centre
Building 70
Monash University
Victoria, 3800

Phone:

Enquiries	(03) 9905 1805
Co-ordinator	(03) 9905 1805
Director	(03) 9905 1857
Fax	(03) 9905 1809
Email:	visu.enquire@monash.edu

All issues of Hazard and other information and publications of the Monash University Accident Research Centre can be found on our internet home page:

www.monash.edu.au/muarc/visu

A Victorian Government initiative

Victoria The Place To Be

VISU is a project of the Monash University Accident Research Centre, funded by the Department of Health

Hazard was produced by the

MONASH University Accident Research Centre

Victorian Injury Surveillance Unit (VISU) with layout assistance of Glenda Cairns, Monash University Accident Research Centre

Illustrations by Debbie Mourtzios and Jocelyn Bell

ISSN-1320-0593

Printed by Work & Turner Pty Ltd, Tullamarine