Centre for
Automotive Safety Research

Pedestrian collisions in South Australia

RWG Anderson

CASR REPORT SERIES
CASR039
February 2008

THE UNIVERSITY
OF ADELAIDE
AUSTRALIA

Report documentation

REPORT NO.	DATE	PAGES	ISBN	ISSN
CASR039	February 2008	58	978-1-920947-38-5	1449-2237

TITLE

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AUTHORS

RWG Anderson

PERFORMING ORGANISATION

Centre for Automotive Safety Research
The University of Adelaide
South Australia 5005
AUSTRALIA

SPONSORED BY

Motor Accident Commission
GPO Box 1045
Adelaide
South Australia 5001
AUSTRALIA

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ABSTRACT

We examine the nature of the decline in pedestrian casualties over the last 25 years. We then examine the changes in crashes in relation to other changes in road crash statistics in South Australia. This is followed by a detailed analysis to estimate the effects of the change in the default urban speed limit that occurred on the 1st of March 2003, when local road speed limits were reduced from 60 km/h to 50 km/h. We also examine some of the characteristics of pedestrian crashes that we have observed during recent in-depth crash studies: in 1999-2000 and 2004-2005, 160 pedestrian crashes were investigated at the scene, and summary data from these studies are presented in this report. This data gives more insight into the characteristics of crashes than can be gleaned from routinely collected police data.

KEYWORDS

Pedestrian, Traffic accident, Injury, Accident statistics, South Australia

Summary

In 2004, 2005 and 2006 there were 32 pedestrian deaths, about 8% of all road deaths, and pedestrian casualties accounted for 6% of all road-related treatments at and admissions to hospital (1,058 recorded treatments and admissions). These numbers indicate that there has been a recent and substantial reduction in pedestrian casualty crashes: in the three years 1994, 1995 and 1996 there were 94 pedestrian deaths, about 18% of all road deaths, and 1,386 pedestrians were treated at, or admitted to hospital (8% of all road casualties).

In the following report, we examine the nature of the decline in pedestrian casualties over the last 25 years. We then examine the changes in crashes in relation to other changes in road crash statistics in SA. This is followed by a detailed analysis to estimate the effects of the change in the default urban speed limit that occurred on the 1st of March 2003, when local road speed limits were reduced from 60 km/h to 50 km/h. We also examine some of the characteristics of pedestrian crashes that we have observed during recent in-depth crash studies: in 1999-2000 and 2004-2005, 160 pedestrian crashes were investigated at the scene, and summary data from these studies is presented in this report. This data gives more insight into the characteristics of crashes than can be gleaned from routinely collected police data.

The decline in pedestrian deaths and casualties over the last 10 years may be explained, at least in part, by lower urban speed limits, and so we might expect further improvements if speed limits were lower on roads currently zoned at 60 km/h. However, changes in casualty and crash numbers may have been affected by reductions in pedestrian exposure – the amount of walking – and so we might expect that pedestrian casualty numbers will be adversely affected by any increases in pedestrian exposure in the future.

Declines in pedestrian casualties since 1990 largely have been due to a decline in casualties 11-20 years of age, and the decline in casualty crashes involving this age group was most pronounced for afternoon crashes. Casualty numbers for pedestrians over 20 changed little over the same period. We speculate that a reduction in exposure for pedestrians under 20 is the most likely explanation for such a decline, however the data on exposure required to demonstrate this is poorly recorded.

Data from the South Australian Department of Health suggest that hospital admissions after crashes are under-reported in the Traffic Accident Reporting System by about 45%. However, we suspect that many are mis-coded as hospital treatments (i.e. treated at the casualty department of hospitals) rather than being omitted completely: Department of Health records lie within the bounds of TARS admissions and admissions plus treatments.

Alcohol use among pedestrians in casualties is high. Around 40% of fatally injured pedestrians had blood alcohol concentrations higher than 0.05 g/l.

Pedestrian fatalities almost all occur on arterial roads with speed limits of 60 km/h, and outside of the Adelaide central business district most casualty crashes also occur on roads with speed limits of 60 km/h.

An analysis of the effect of the introduction of the 50 km/h speed limit suggests that the reduced speeds that have occurred since the change have been associated with substantial and significant declines in pedestrian casualties. In South Australia, the change to 50 km/h limits was associated with a 36% reduction in pedestrian casualties on those roads. Concomitantly, a 15% reduction in pedestrian casualties on arterial roads that retained a speed limit of 60 km/h was observed (over and above the longer-term decline in pedestrian casualties). Similar reductions were observed in the Adelaide CBD, and no fatality has occurred in the CBD on 50 km/h streets since the introduction of the new limit. The reductions compare favourably with speed-related reductions predicted for Adelaide in 1997 (Anderson et al., 1997).

A summary of in-depth data collected by the Centre for Automotive Safety Research since 1999 shows that the type and severity of injuries sustained by pedestrians in collisions in Adelaide is consistent with the focus of test procedures being used to assess the pedestrian safety of vehicle designs. Two thirds of severe injuries sustained in pedestrian crashes were to the head and legs of the struck pedestrians. However, a significant proportion of head impacts occurred with parts of the vehicle beyond the limit of the test area specified by such test procedures.

The ages of vehicles involved in pedestrian crashes highlight the fact that new technology that might be implemented in the future to improve pedestrian protection may take some years to penetrate the South Australian vehicle fleet. An Australian Design Rule on pedestrian protection might accelerate the introduction of safer passenger vehicles into the vehicle fleet.

Contents

1 Introduction

In 2006, pedestrian deaths accounted for about 10% of South Australia's road toll (12/117 deaths). Pedestrian deaths have reduced in number and as a proportion of all deaths over the last decade. In the three years 1994, 1995 and 1996 there were 94 pedestrian deaths, about 18% of all road deaths. In 2004, 2005 and 2006 there were 32 pedestrian deaths, about 8% of all road deaths. Compare these figures with other crash types: in 2004-2006, nearly three quarters of road fatalities have occurred to car occupants, and around 16 % to motorcycle riders.

The decline in pedestrian casualties has been less pronounced than the decline in fatalities; The South Australian Traffic Accident Reporting System records that in 1994-1996, 1,386 pedestrians were treated at, or admitted to hospital, which was around 8% of all road-related treatments and admissions. A decade later, the number has fallen to 1,058 and 6% of road related treatments and admissions.

As this report will show, the decline in pedestrian deaths and casualties may be explained, at least in part, by lower urban speed limits, and so we might expect further improvements if speed limits were lower on roads currently zoned at 60 km/h. However, changes in casualty and crash numbers may have been affected by reductions in pedestrian exposure – the amount of walking – and may be adversely affected by any increases in pedestrian exposure in the future.

For vehicle design, the first response to the figures might be to relegate pedestrian safety to a lower priority than occupant safety, given that 9 times as many occupants were killed in the three years to 2006. However, such a response may be misguided: when one considers the attention given to different crash modes that constitute the ways in which occupants can be injured and killed, a slightly different picture emerges. In all ways that one may examine the data, the most common crash type leading to injury or death recorded in the South Australian Traffic Accident Reporting System (TARS) is 'hit fixed object', commonly single vehicle crashes. Occupants killed in 'hit fixed object' crashes account for 33% of all road deaths (Table 1.1). Occupants killed in 'Head on' and side impact crashes ('right angle' plus 'right turn') account for around 15% and 11% of all road deaths. Then 'roll over' and 'pedestrian' account for 8% each. (Noteworthy too is that 'riders' of motorcycles and bicycles are 18% of all road deaths.) When metropolitan crashes only are considered, pedestrian fatalities rank second after occupants killed in 'hit fixed-object' crashes and ahead of side impact crashes, and outrank head-on crashes as a source of injury and death. Therefore, the relative importance of pedestrian safety from improved vehicle design emerges after disaggregation of crashes by crash type.

Table 1.1
Disaggregation of South Australian road fatalities, 2004-2006

Road user type	Crash type	Percentage of fatalities
Vehicle occupants	Rear end	2%
	Hit fixed object	33%
	Side swipe	3%
	Right angle + right turn	11%
	Head on	15%
	Roll over	8%
	Other	1%
Pedestrians	All	8%
Riders	All	18%

Recent changes in the crash and casualty numbers provoke us to enquire into the nature of those changes and the characteristics of pedestrian crashes today. In the following report, we examine the nature of the decline in pedestrian casualties over the last 25 years. We then examine the changes in crashes in relation to other changes in road crash statistics in SA. This is followed by a detailed analysis to estimate the effects of the change in the default urban speed limit that occurred on the 1st of March 2003, when local road speed limits were reduced from 60 km/h to 50 km/h.

Finally we examine some of the characteristics of pedestrian crashes that we have observed during recent in-depth crash studies: in 1999-2000 and 2004-2005, 160 pedestrian crashes were investigated at the scene, and summary data from these studies are presented in this report. This data gives more insight into the characteristics of crashes than can be gleaned from routinely collected police data.

2 Characteristics of crashes

2.1 Demographics

Figure 2.1 shows the distribution of the age of all pedestrian casualties recorded in the South Australian Traffic Accident Reporting System from 1981 – 2005. It shows that people under 30 are over represented. There is a notable peak in the distribution of 20 year old pedestrians.

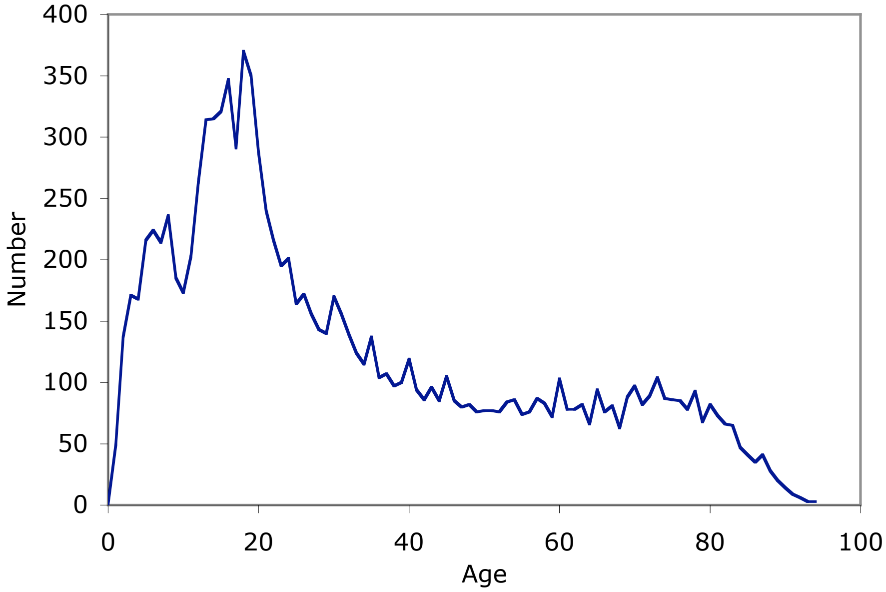

Figure 2.1
Distribution of ages of pedestrians injured in crashes
(treated at hospital, admitted, or fatally injured) in South Australia, 1981-2005 (Source: TARS)

This chart belies the fact that there have been significant changes in the profile of pedestrian casualties between 1981 and 2005. Figure 2.2 shows smoothed distributions[1] for the year 1981 and 2005. The scale for the 1981 distribution covers twice the range of the scale used for the 2005 distribution. It is apparent that the yearly number of casualties has approximately halved over the intervening period. It is also apparent that the details of the distributions are different indicating that the age composition of pedestrian casualties has altered. Trends in the demographic composition of pedestrian casualties are presented and discussed in more detail in Section 2.2 of this report.

The distribution of the ages of fatally injured pedestrians from 1981 to 2005 is shown in Figure 2.3. A comparison with the distribution shown in Figure 2.1 indicates that the relative risk of being killed if injured in a pedestrian collision is not uniform at every age. The relative risk of being killed is indicated by the case fatality rate, which is the number of fatalities as a proportion of all casualties. The case fatality rate in pedestrian casualty crashes is shown in Figure 2.4. The case fatality rate may be determined by not only the susceptibility of pedestrians to fatal injuries by age, but also by the severity of crashes that pedestrians of particular ages are exposed to. So for example, if school aged children who are struck by traffic are, on average, in lower speed environments than young adults who are struck by

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[1] Smoothing has been employed in the presentations of some distributions in this report, specifically where the number of casualties or crashes is small. The smoothing used a centred 5-point moving average over each year-of-age category.

traffic, this may explain some of the variance in the case fatality rate. Similarly, young children struck by traffic may more routinely be treated or admitted to hospital than adults, who might instead consult a general practitioner for a similar minor injury. Hence children with more minor injuries may be over-represented in the data in Figure 2.1, lowering the apparent case-fatality rate.

Nevertheless, it is apparent that the susceptibility of pedestrians to fatal injuries increases generally with age, such that one in six pedestrian crashes involving the elderly are fatal.

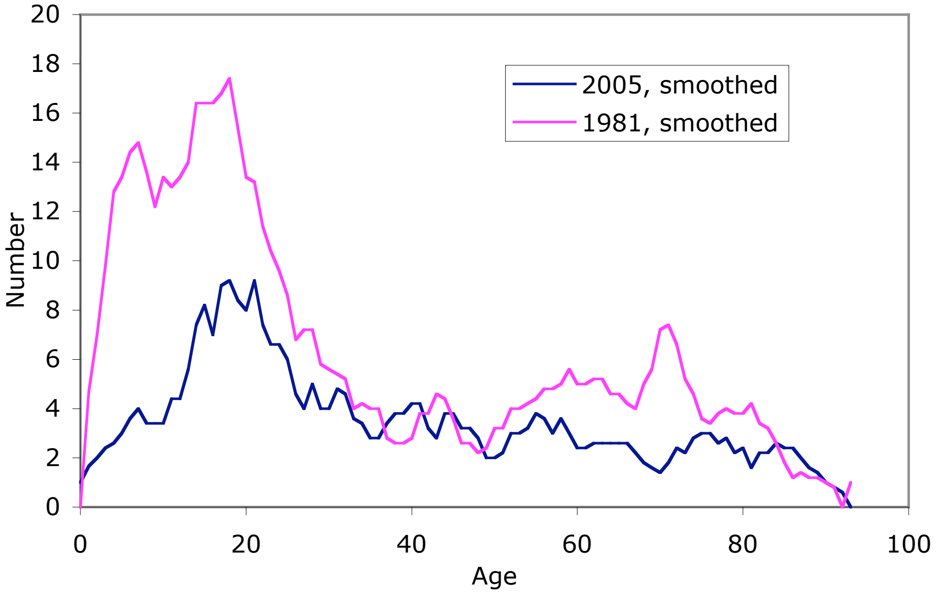

Figure 2.2
Smoothed distribution of ages of pedestrians injured in crashes
(treated at hospital, admitted, or fatally injured) in South Australia in 1981 and in 2005 (Source: TARS)

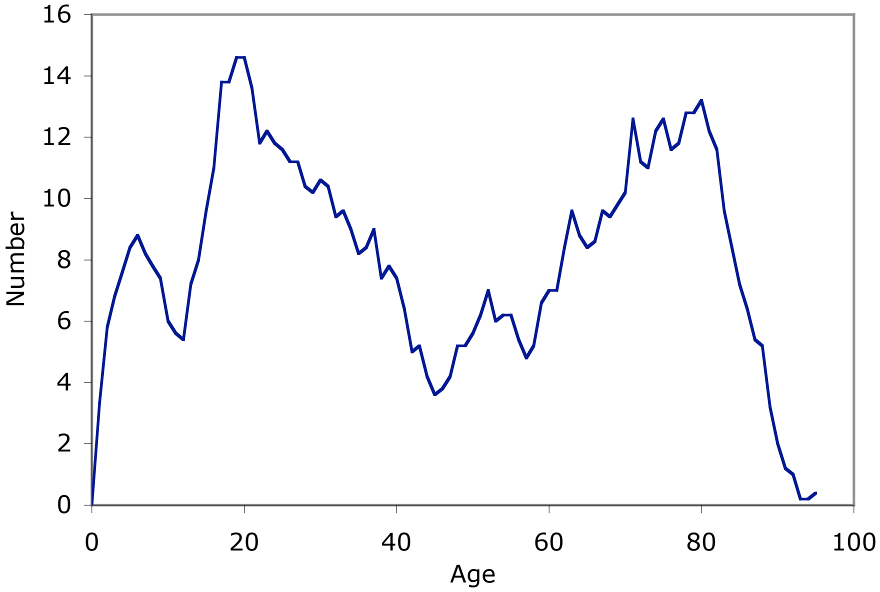

Figure 2.3
Smoothed distribution of ages of fatally injured pedestrians, 1981-2005 (Source: TARS)

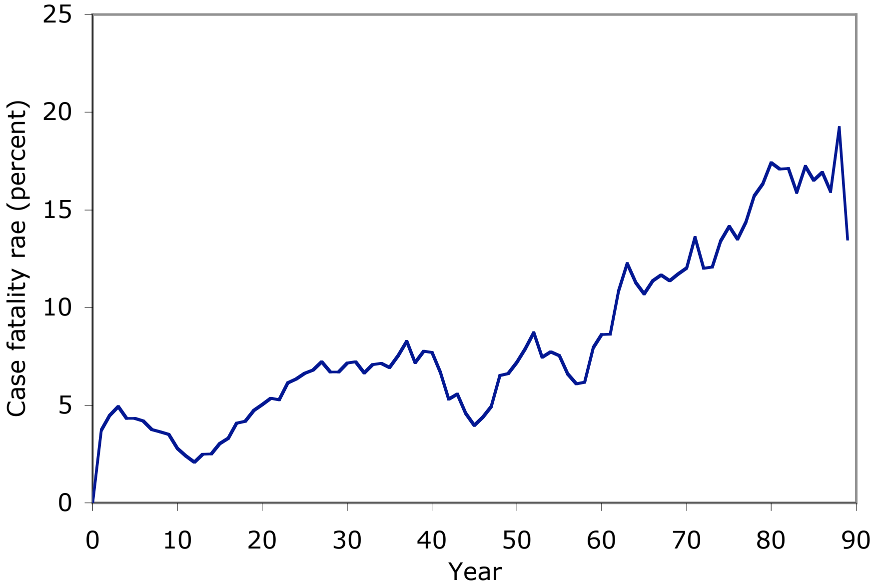

Figure 2.4
Smoothed case fatality rate of injured pedestrians
(treated at hospital or more severe), 1981-2005 (Source: TARS)

2.2 Trends in the number of pedestrian casualties

As noted in Section 2.1, there have been notable changes in the frequency and age distribution of pedestrian casualties between 1981 and 2005. Figure 2.5 shows the rolling 12-month total of monthly pedestrian casualties in South Australia. (Note that the year scale in this Figure is such that the number of casualties at each year corresponds to the 12 months ending December 31 of that year.) Also, as a precursor to Section 4 of this report, in which the effect of the introduction of 50 km/h urban speed limits is discussed, Figure 2.5 also shows the rolling 12 month totals of pedestrian casualties on roads now subject to limits of 50 km/h and 60 km/h. (See Section 4 for details on how these crashes were identified.) The period denoted by the dashed bars indicates data that includes the transition from 60 km/h to 50 km/h speed limits in urban areas.

There are several noteworthy phases in this data, which will be discussed in detail below. The three phases that will be referred to are the periods 1981–1990, 1991–2001, and 2002–2005.

Affecting the number of pedestrian casualties from year to year are factors such as population and demographic changes, changes in exposure (e.g. the amount of walking) and changes in risk, and explaining the change in the number of pedestrian crashes requires us to consider as many of these factors as we can.

First, noting that the rate of reported pedestrian casualties has changed, we also note that this has happened unevenly among the population; Figure 2.6 shows the population-based rate of pedestrian casualties by age from different years spanning 1981 to 2005 and it is notable that declines in the rate of pedestrian casualties among age groups have occurred during different periods, and the rate for other age groups has not changed much at all. Population data are drawn from the Australian Bureau of Statistics (2006).

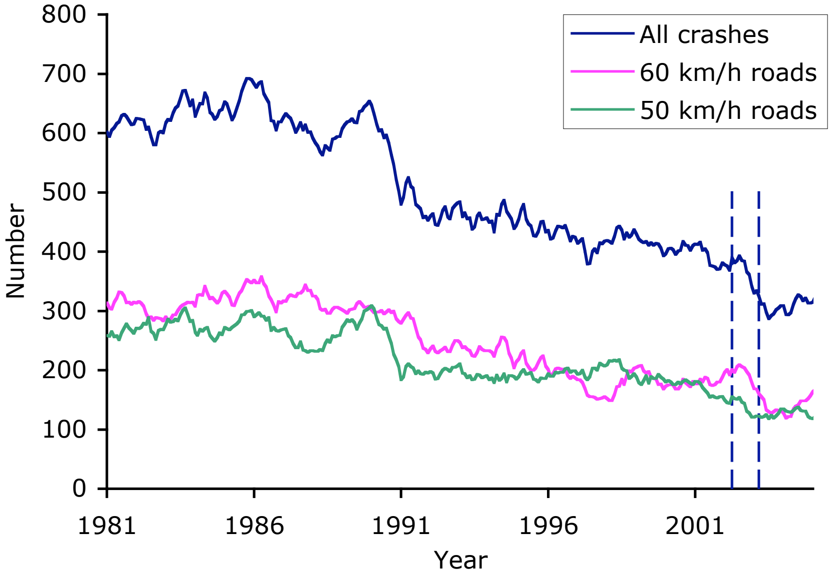

Figure 2.5
Trend in the rolling 12-month totals of monthly pedestrian casualties
(treated at hospital or more severe) by age group (Source: TARS)

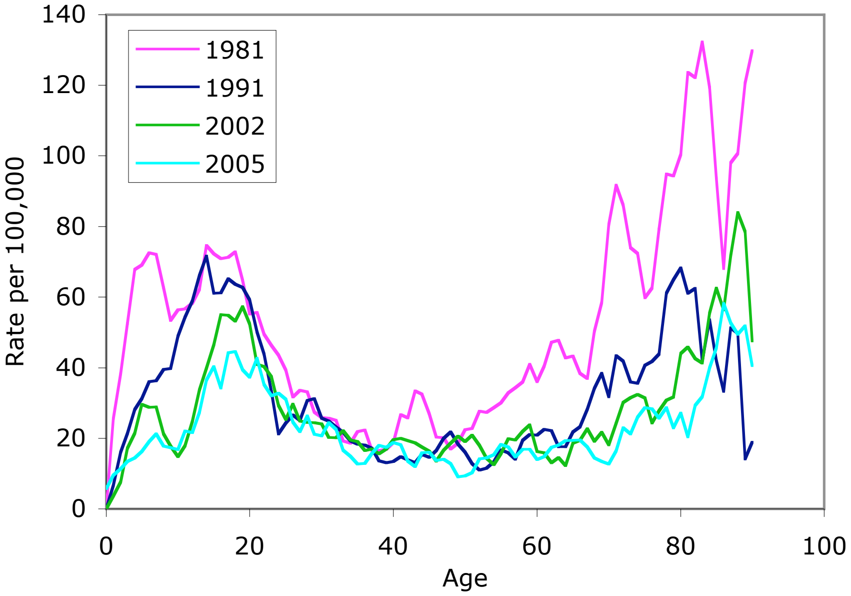

Figure 2.6
Smoothed population based rates of pedestrian casualties in South Australia from 1981 to 2005
(Source: TARS and ABS, 2006)

2.2.1 Changes between 1981 and 1991

Figure 2.7 shows the age distribution of pedestrian casualties in 1981 and 1991. The differences between these two distributions are shown in Figure 2.8 with the age distribution of the change in the population of South Australia over the same period. It is immediately noticeable that the change in the demography of the State over this period does not explain the general lowering in the number of pedestrian casualties although it appears to explain some of the differences in the change in casualty numbers between age groups. The difference between these two distributions is shown in Figure 2.9 and the Figure shows that the changes in the pedestrian casualty rate per population were greatest for pedestrians less than 7 years of age and pedestrians over 40.

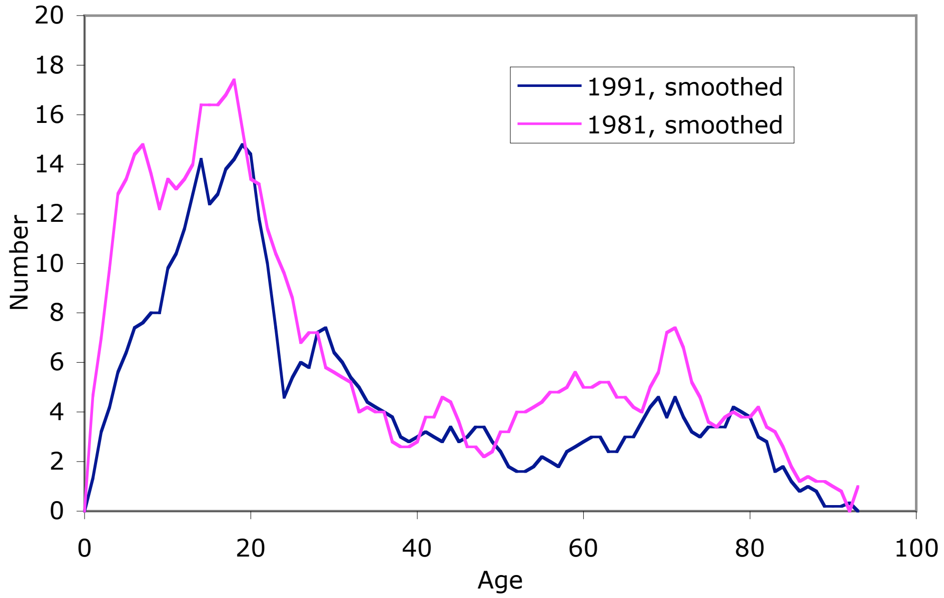

Figure 2.7
Smoothed distribution of ages of pedestrians injured in crashes
(treated at hospital, admitted, or fatally injured) in South Australia in 1981 and in 1991 (Source: TARS)

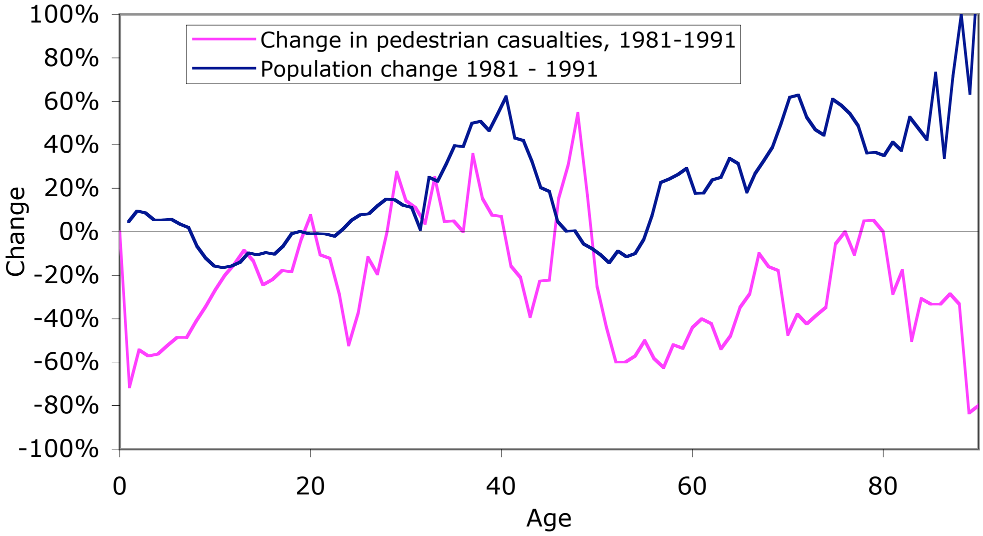

Figure 2.8
The age distribution of the change in pedestrian casualties between 1981 and in 1991
and the age distribution of the change in population between June 1981 and June 1991
(Source: TARS and ABS, 2006)

If we assume that the population-based rate of pedestrian casualties did not change between 1981 and 1991, we can calculate an expected age distribution of pedestrian casualties in 1991 based on the distribution in 1981 and the change in the demographic composition of the State. This expected distribution for 1991 is shown in Figure 2.10 with the actual distribution. The difference between these two distributions is shown in Figure

2.11. The declines in pedestrian casualties aged less than 7 and over 40 are apparent in these figures.

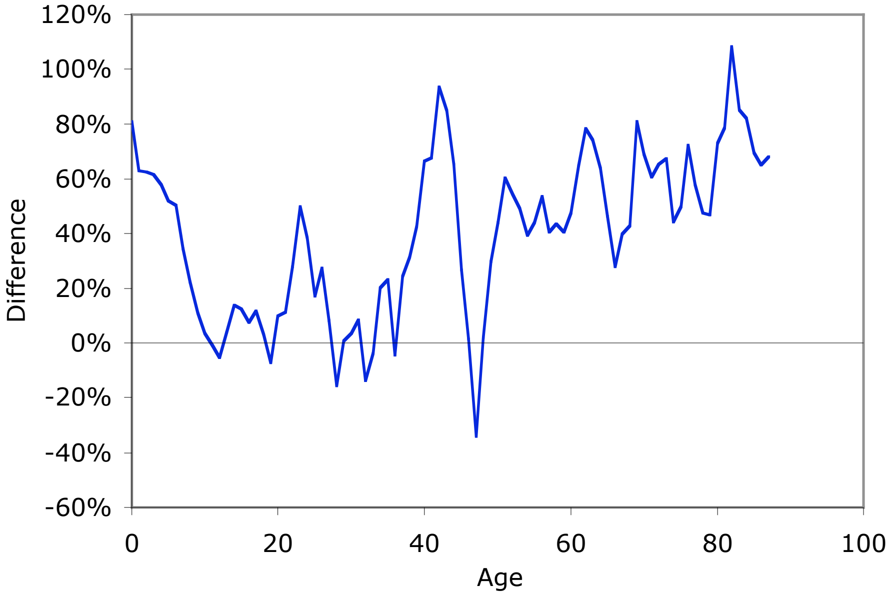

Figure 2.9
Age distribution of the difference between the change in pedestrian casualties and the change in the population 1981-1991 (Source: TARS and ABS, 2006)

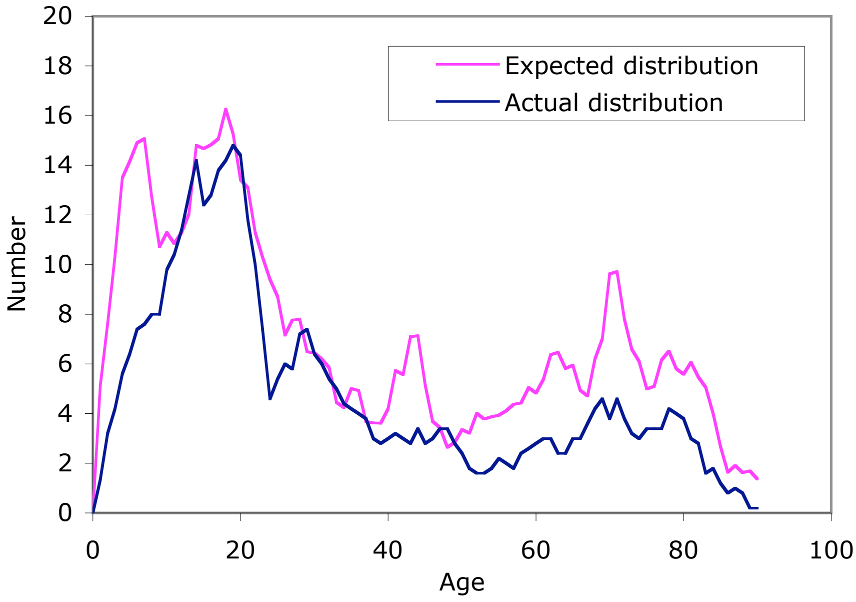

Figure 2.10
Expected age distribution of pedestrian casualties in 1991 based on the 1981 distribution and the changes in the age distribution of the population between 1981 and 1991.
The actual age distribution of pedestrian casualties in 1991 is shown in blue.

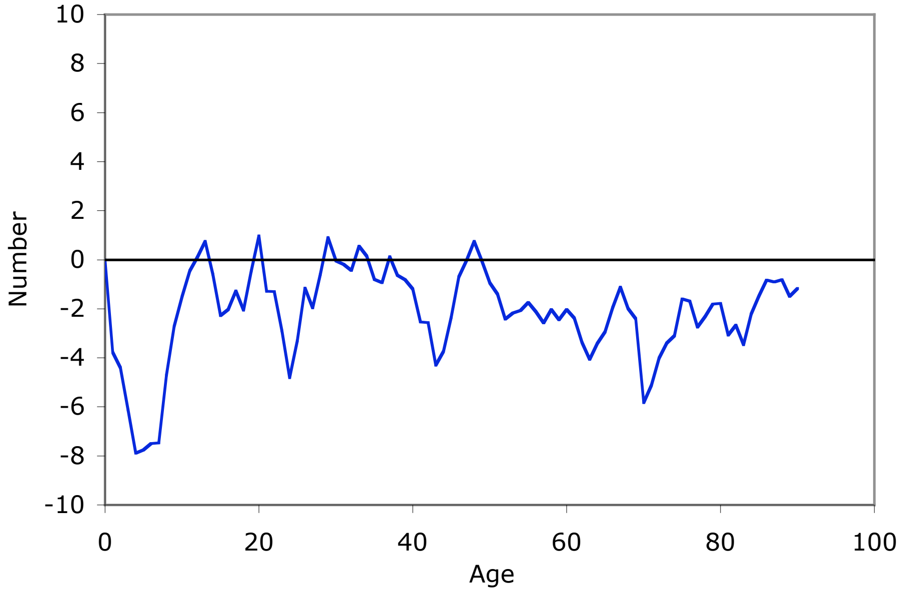

Figure 2.11
Difference in the number of pedestrian casualties by pedestrian age; 1981 and 1991

2.2.2 Changes between 1991 and 2002

Turning now to the period between 1991 and 2002, a marked change in the age distribution of pedestrian casualties is also apparent (Figure 2.12). The change during this period is partly explained by the change in the age composition of the State's population. Figure 2.13 shows the age distribution of the change in the number of pedestrian casualties and the population. The relationship between these two distributions is apparent. The difference between these two distributions (Figure 2.14) shows that the population risk improved for those less than 20 years of age and those over 60 years of age. However, the population risk slightly worsened for people between these ages.

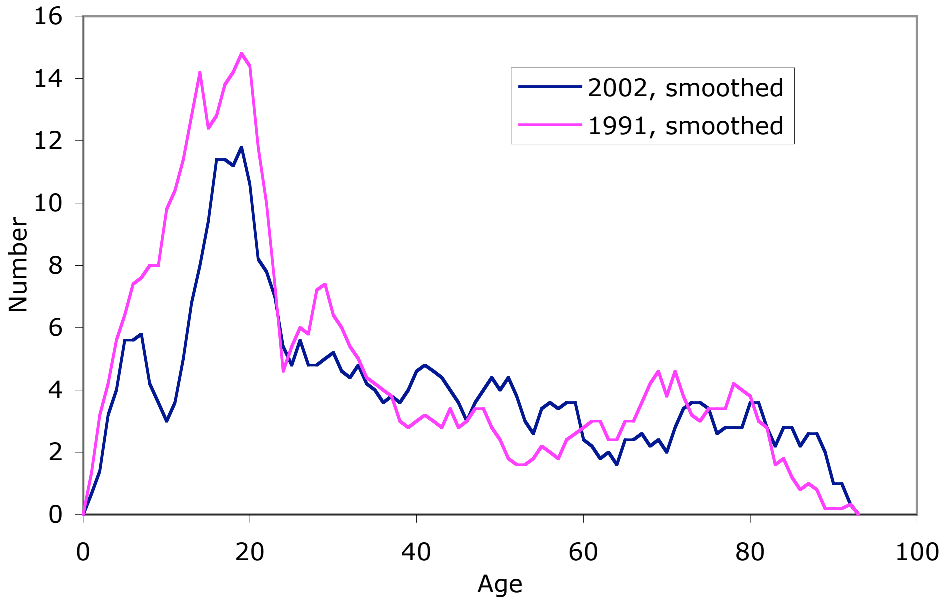

Figure 2.12
Smoothed distribution of ages of pedestrians injured in crashes
(treated at hospital, admitted, or fatally injured) in South Australia in 1991 and in 2002 (Source: TARS)

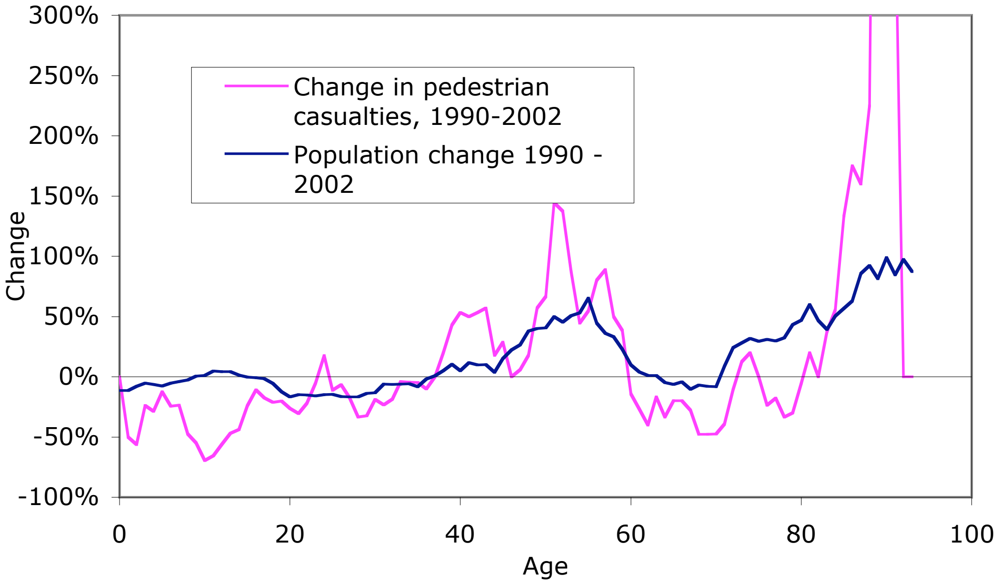

Figure 2.13
The age distribution of the change in pedestrian casualties between 1991 and in 2002
and the age distribution of the change in population between June 1991 and June 2002
(Source: TARS and ABS, 2006)

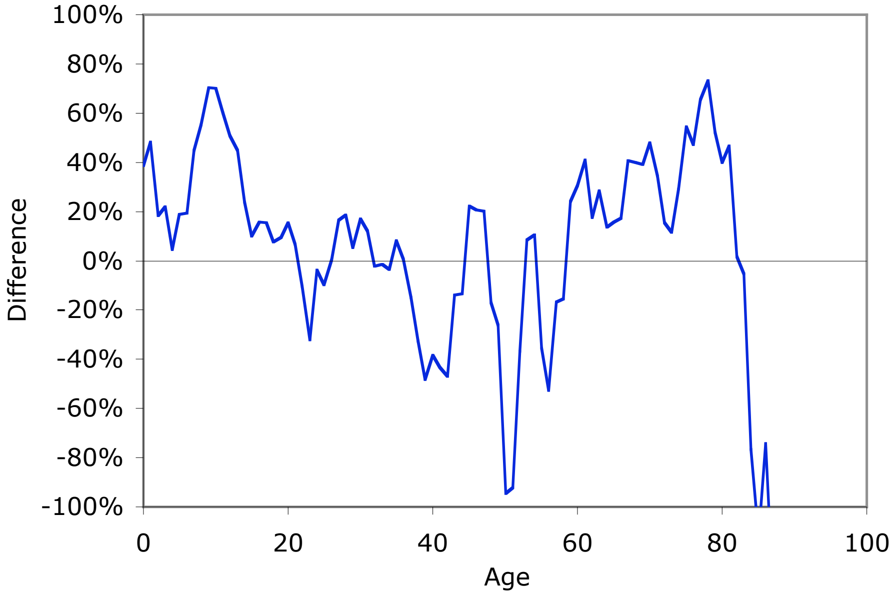

Figure 2.14
Age distribution of the difference between the change in pedestrian casualties and the change in the population, 1991-2002

Applying the rate of pedestrian casualties by age in 1991 to the population in 2002 gives the age distribution of pedestrian casualties expected if the rate in each age group had not changed over the period. The expected distribution and the actual distribution are shown in Figure 2.15 and the difference in Figure 2.16. Here a large reduction in casualties aged between 7 and 16 years is apparent, as is a decline in casualties aged between 60 and 80. For the population aged between 20 and 60, there was, on average, a slight increase in the adjusted number of casualties.

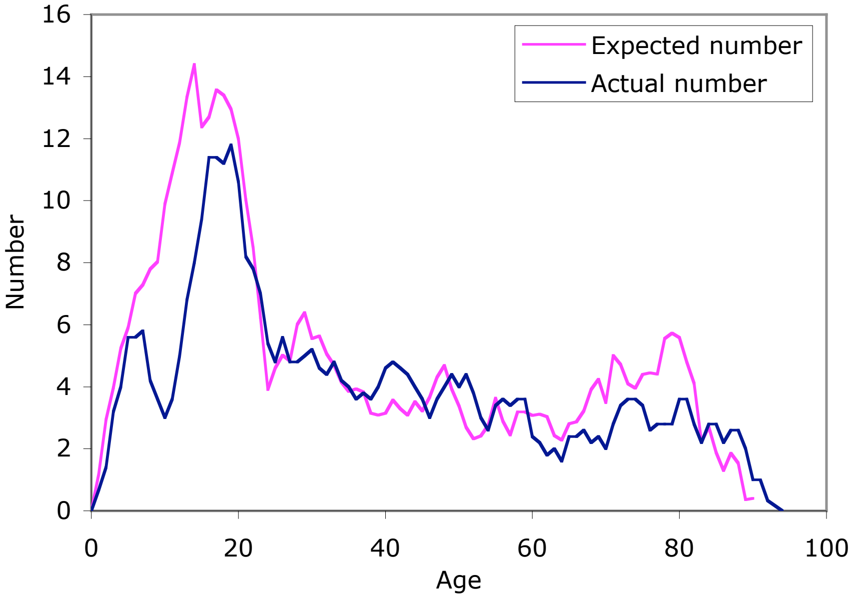

Figure 2.15
Expected age distribution of pedestrian casualties in 2002 based on the 1991 distribution and the changes in the age distribution of the population between 1991 and 2002

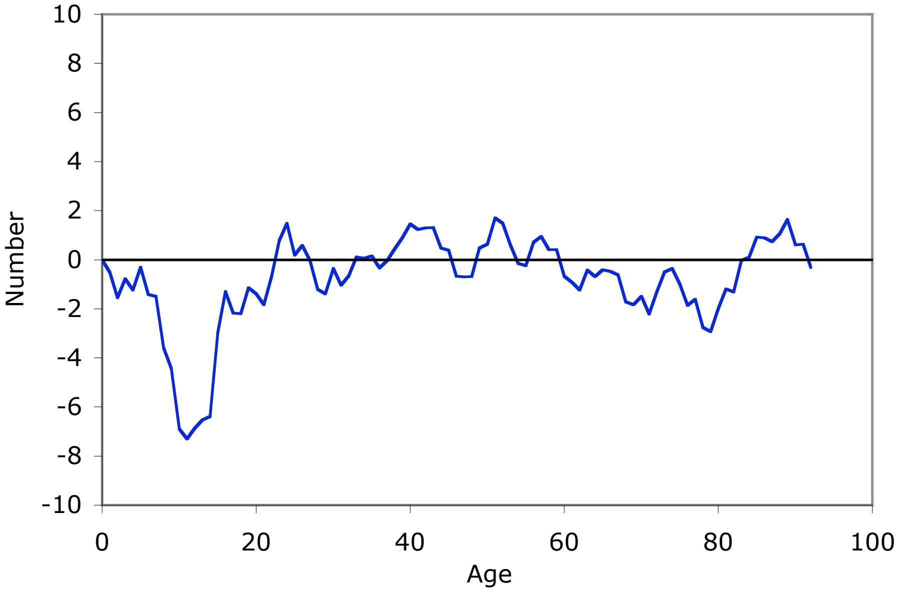

Figure 2.16
Difference in the number of pedestrian casualties by pedestrian age between 1991 and 2002

2.2.3 Changes between 2002 and 2005

The last and most recent period to be discussed in this Section is the short period between 2002 and 2005. Being a short period, we expect that any shift in the age distribution of the population to be minor (although it will be accounted for). The period is of particular interest as it spans the introduction of a lower default urban speed limit on the 1st of March 2003, from 60 km/h to 50 km/h. Not all urban roads had the lower limit applied, and the roads subject to each limit account for roughly equal numbers of pedestrian casualties (see Figure 2.5). The effect of this change is treated more formally in Section 4, however here any change in the age distribution of casualties will be examined.

The distribution of the ages of pedestrian casualties for the years 2002 and 2005 are shown in Figure 2.17. A slight decline is apparent, and adjustment for population changes (Figure 2.18) confirms that the changes in casualties are spread uniformly across age categories. The anomaly between the expected distribution based on the 2002 distribution and actual distribution for 2005 (Figure 2.19) shows a drop in casualty numbers more uniformly distributed over all ages than the earlier periods of 1981-1991 and 1991-2002.

Figure 2.17
Smoothed distribution of ages of pedestrians injured in crashes
(treated at hospital, admitted, or fatally injured) in South Australia in 2002 and in 2005

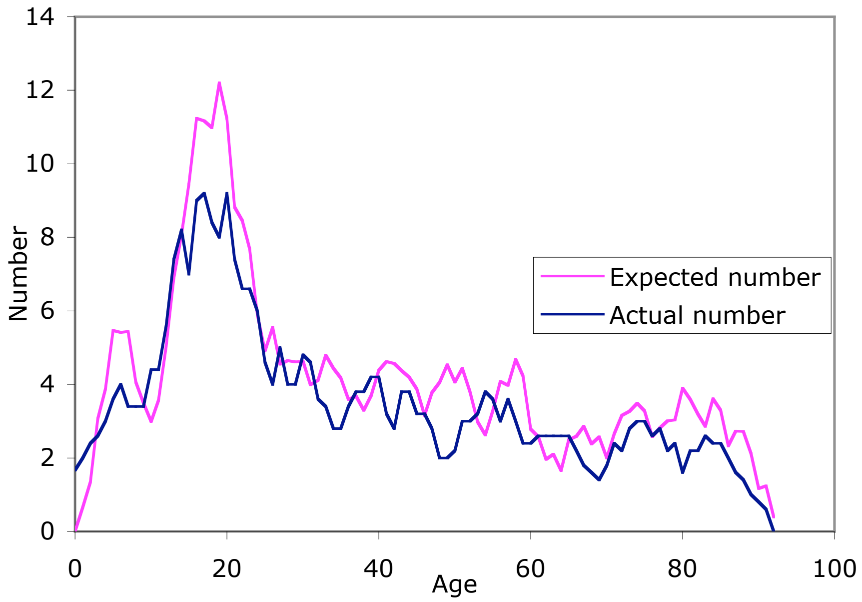

Figure 2.18
Expected age distribution of pedestrian casualties in 2005 based on the 2002 distribution and the changes in the age distribution of the population between 2002 and 2005. The actual age distribution of pedestrian casualties in 2005 is shown in blue.

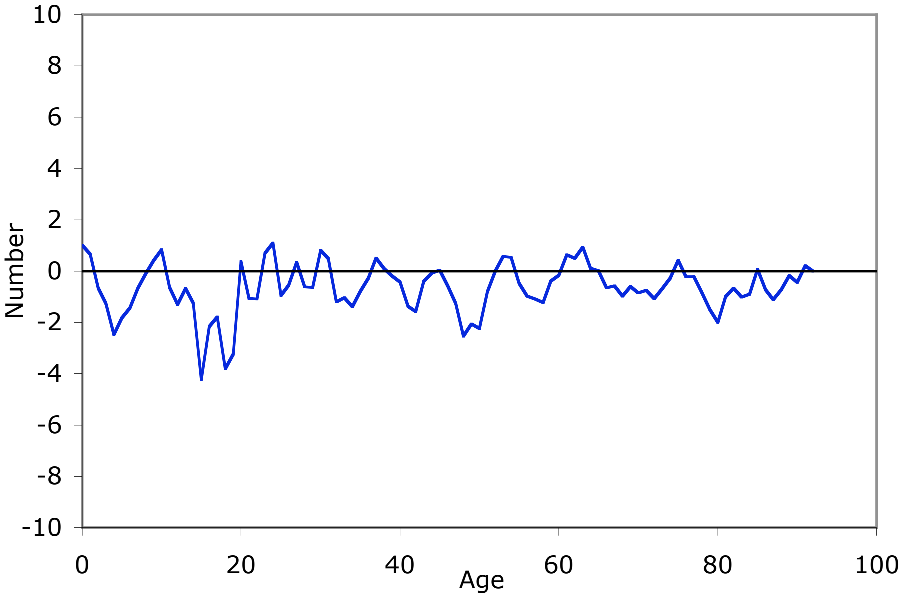

Figure 2.19
Difference in the number of pedestrian casualties by pedestrian age; 2002 and 2005

2.2.4 Further analysis on the recent decline in the number of young pedestrian casualties

As noted in previous Sections, there has been a notable decline in the number of young pedestrian casualties. Figure 2.20 and Figure 2.21 show trends in the number of casualties by age group, 1990 to 2005, the latter for more severely injured casualties. Numerically, the largest decline has occurred among pedestrians aged 11-20, but proportionally the greatest decline has occurred among those aged 1-10 (rates of -6.7% p.a. for treated+ and -9.9% p.a.

for admissions+). The second largest decline is casualties aged 11-20 (rates of -4.1% p.a. and -7.4% p.a.) These declines have occurred during a period where casualties among other age groups have not changed nearly as much.

Casualties 20 years old and younger have declined at an average rate of 5.1% per annum over the 16 year period 1990-2005. This has occurred almost evenly by time of day. (Morning, afternoon and night crashes have declined by 5.6%, 5.3% and 4.1% p.a., respectively.) However, the afternoon (8 hour period starting at 1 pm) has seen the largest numerical decline in casualty crashes.

The difference between casualty numbers among age groups has already been presented in previous sections in this report. It is emphasised further by Figure 2.22. The average decline in pedestrian casualties of those over 20 years old was 1.4% per annum between 1990 and 2005. The difference between this rate and the rate for young pedestrians tends to suggest a decline in exposure may be the best explanation for the reduction in crashes among the young. Some discussion about changes in exposure is given in Section 2.2.5 of this report.

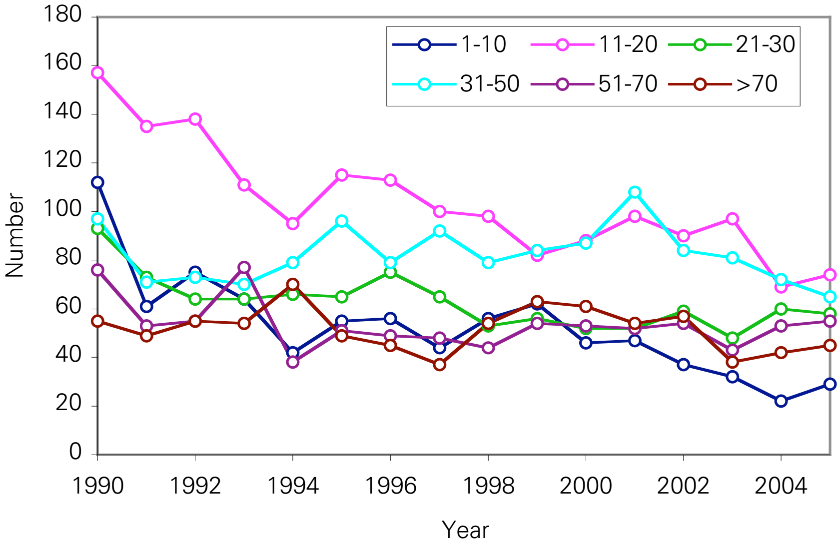

Figure 2.20
Trend in yearly totals of pedestrian casualties (treated at hospital or more severe) by age group

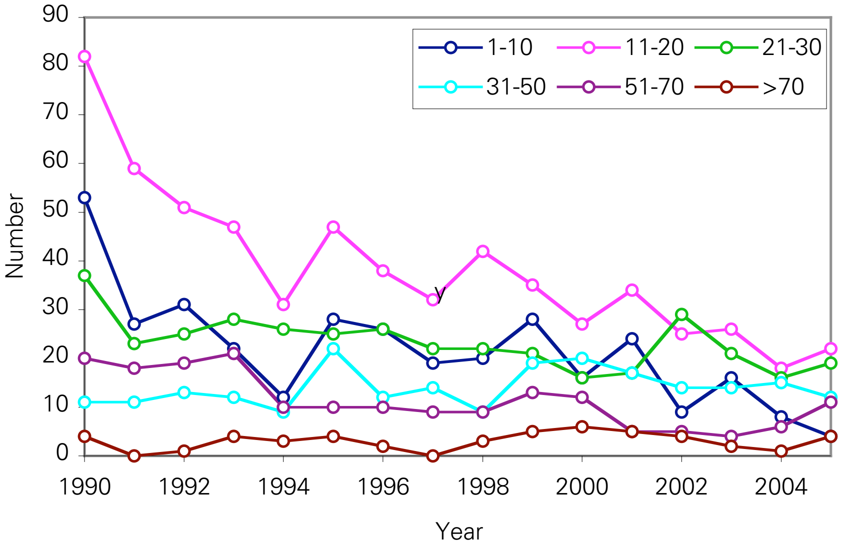

Figure 2.21
Trend in yearly totals of higher severity pedestrian casualties (admitted to hospital or fatal) by age group

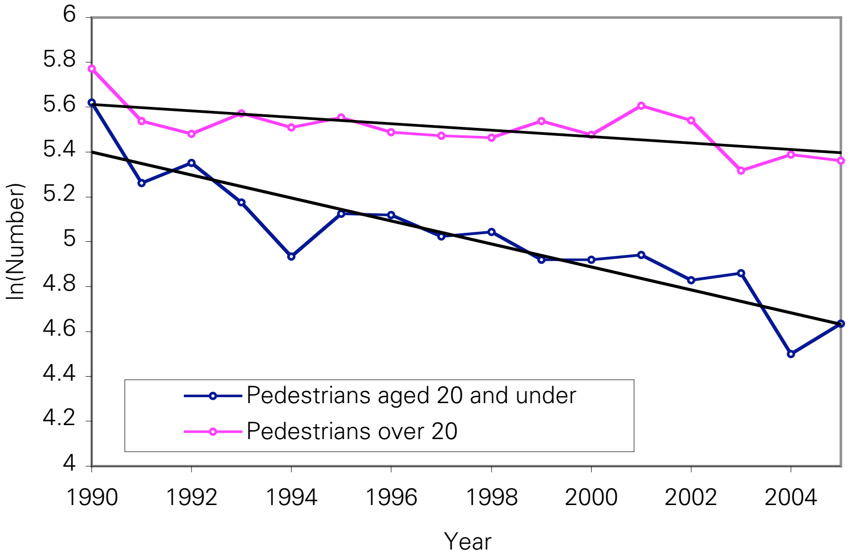

Figure 2.22
The logarithm of the annual numbers of pedestrian casualties aged 20 or younger (treated at hospital, admitted to hospital or fatal) and those over 20.
A straight line on such a chart is a constant rate of change. The straight lines in this chart represent the average rate of decline in the numbers in each age group.

To explain trends in casualty numbers, one should consider both changes in exposure (e.g. the amount of walking) and changes in risk (e.g. changes in road crossing behaviour, and changes in vehicle speed). To explain the profound decline in the number of young pedestrian casualties we are inclined to suggest that a change in exposure may be the most plausible (although not the only) explanation. Unfortunately, relevant exposure measures are poorly documented. Given that the number of crashes can be conceptualised as being the product of risk and exposure to that risk, rather little attention has been given to understanding how exposure is changing, and instead we can only infer the possible presence of it from patterns in the crash data itself, and anecdotal trends in exposure related phenomena (changes in the amount of walking to and from school, for example).

The only relevant figure that we were able to find in relation to exposure comes from the Adelaide Household Travel Surveys conducted in 1986 and 1999 (Transport SA, 2002). These surveys show that between 1986 and 1999, walking trips declined by 20 percent. Pedestrian casualties (treated at hospital+) and fatalities declined by 30 percent during that period. Thus it would seem that trends in exposure need to be understood more fully; if the reduction in crashes we have seen is partly due to a reduction in exposure, any increase in the amount of walking would see pedestrian crashes increase.

2.2.5 Relative trends in driver and pedestrian casualty numbers

Figure 2.23 shows the number of pedestrian and driver casualties over the period from 1990 to 2005. It is apparent that after 1995, the trends in the numbers of driver and pedestrian casualties diverge. The data is shown in Figure 2.24 as the ratio of pedestrian casualties to driver casualties. The decline in this ratio is remarkably linear.

As with other data presented in this report, the interpretation of such information is made more difficult because we lack the relevant exposure measures for South Australia (e.g. the numbers of walking trips) that might assist us in determining what proportion of this trend is attributable to changes in risk and what proportion to exposure. However in Section 2.2.4, we suggested that many of the recent changes in young pedestrian casualties were related to changes in exposure, and given that walking trips had declined by 20 percent between 1986 and 1999, further declines since 1999 are plausible.

In support of exposure as a possible explanatory variable for the trend in Figure 2.24, a linear 15 percent decline in personal walking exposure was observed in the United Kingdom over the eight years between 1996 and 2002 while personal driving exposure remained almost constant over the same period (Department for Transport, 2006). If similar relative exposure trends (walking:driving) occurred in South Australia they might lead to the trend illustrated in Figure 2.24. Note that this does not imply that walking or driving has become more or less safe over the period, but that relative numbers in each category may be dominated by the change in exposure over the period. However, the obvious implication is that the number of pedestrian injury crashes relative to occupant injury crashes is subject to relative changes in exposure in each group.

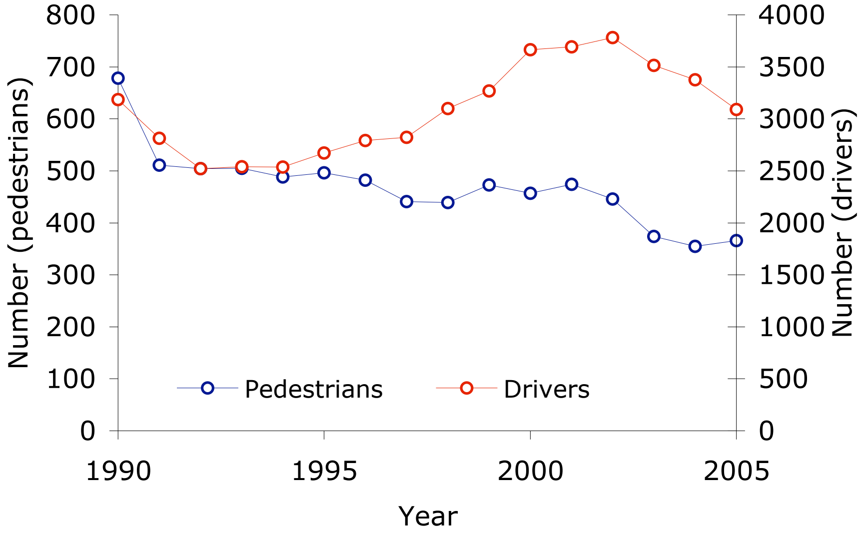

Figure 2.23
Pedestrian and driver casualties (treated at hospital or more severe) in South Australia 1990-2005

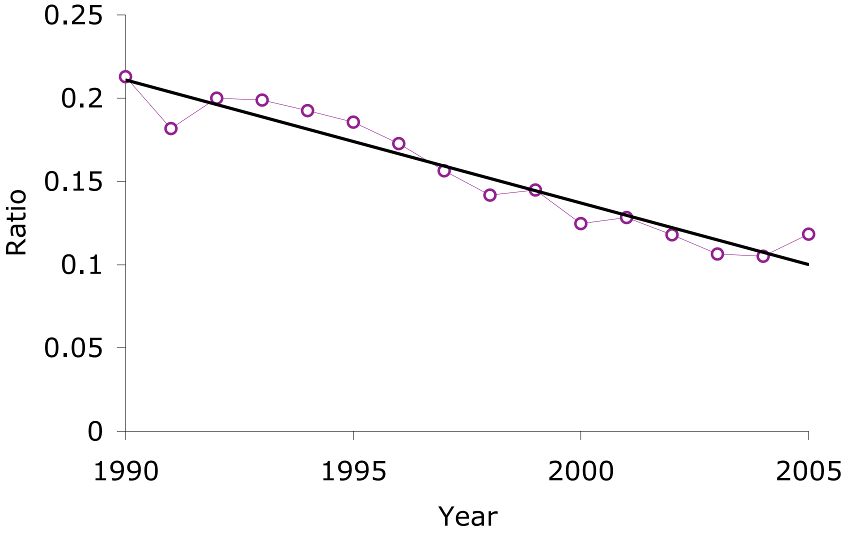

Figure 2.24
The ratio pedestrian:driver casualties (treated at hospital or more severe) in South Australia, 1990-2005

2.3 Data from the South Australian Department of Health

Another source of data on pedestrian casualties is maintained by the South Australian Department of Health. On the discharge of every patient from hospital, a "separation" record is produced that details certain information, including the treatment received, the cause of the admission, personal details and certain other items of information. The Department of Health collates this information.

The cause of the admission is also recorded and is known in the system as the "external cause". It is coded according to the International Classification of Diseases, currently in its 11th edition (ICD11). The ICD codes include categories for traffic accidents and include specific categories for pedestrian crashes. Data since 1990 was either coded to ICD9 or ICD10.

Used carefully, the separations data can be used to describe numbers of pedestrians injured and admitted to hospital, and trends in this data. Importantly, the data may be compared to police records, and underreporting in either database can be estimated.

For this report, the database maintained by the Department of Health was queried to produce separation records for all pedestrian casualties. The data included people who were discharged in the years 1990-2005, whose records conformed to the following criteria:

- If coded to ICD 10, external cause code in the range V011 to V099 (Pedestrian injured in transport accident), excluding codes ending in a 0 and V091 (Non-traffic accidents).
- If coded to ICD 9, external cause code E81*7, where * is in the range 1 to 6 or 9 (thus excluding non-collisions and train accidents).
- The reason for the separation was not because of death.
- All sources of admission were excluded other than casualty wards, private medical practices, and those that were of unknown origin. This eliminated administrative admissions, inter-hospital transfers and other such sources that would lead to double counting some admissions.

The resulting database of admissions was analysed and the results are discussed below.

2.3.1 Age distribution and trends in pedestrian casualty hospital separations

Figure 2.25 shows the distribution of the ages of pedestrian casualties discharged from hospital in the years 1990 to 2005. This Figure also indicates those casualties who were admitted from a private medical practice (as police may have coded these cases as "treated by doctor") and those who came from an unknown source. Also shown in Figure 2.25 are the numbers of admissions and those either treated at, or admitted to, hospital, as recorded in the South Australian Traffic Accident Reporting System.

While the distributions are similar in shape, it is clear that more pedestrian casualties are being recorded as being admitted to hospital than the police records would indicate. There are two obvious sources of discrepancy: firstly, casualties who are admitted to hospital may be incorrectly coded as "treated by doctor" or "treated at hospital" in the TARS database. Given that the separations data lie within the envelope bounded by the categories of TARS "admitted" and TARS "treated or admitted" (Figure 2.25) this is certainly a plausible explanation. It is notable that the separations for very young children and those over 80 accord with the "treated or admitted" numbers in TARS, and one might speculate that the very young, and the elderly would be admitted as a matter of procedure, and it would therefore be likely that pedestrians of these ages may be incorrectly coded as being only treated at hospital, when they are, in fact, admitted to hospital. Secondly, it is probable that some admissions may not be reported to police at all. However, if the injuries are sufficient to warrant hospital admission, it is unlikely that this number is relatively large, given the legal requirement to report all casualty crashes to the South Australian Police, and the ease with which a miscoding of the first type might be made by the reporting police officer.

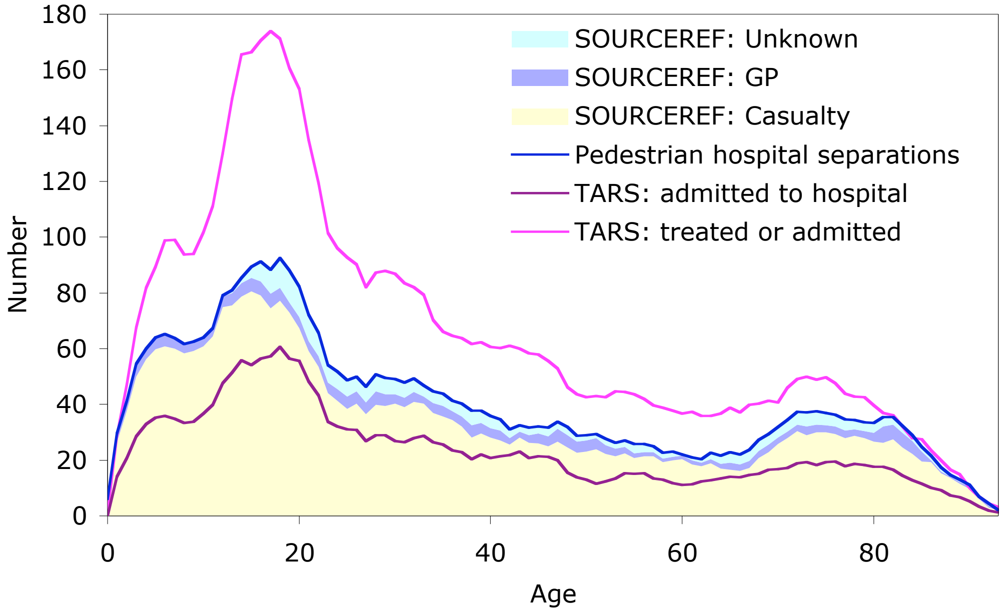

Figure 2.25
The age distribution of pedestrian hospital separations during the years 1990-2005,
with the components according to patient source (variable SOURCEREF) indicated.
Data on hospital treatments and admissions from TARS during the same period is also shown.

The proportion of admitted cases apparently missing from the TARS database from 1990-2005 is around 45%. The proportion is shown in Figure 2.26 by age of casualty. However, given that it is likely that many of these missing cases have been miscoded as treated at hospital, we might expect the total number of casualties (defined as treated at hospital plus those admitted to hospital) to be closer to the total number of those seeking treatment at hospital after a pedestrian collision.

Trends in the total number of hospital separations are compared with the trend in TARS recorded hospital admissions in Figure 2.27. Similar declines in the number of such casualties over the period 1990 to 2005 are apparent. It is therefore reasonable to use records in TARS to assess trends in these types of crashes.

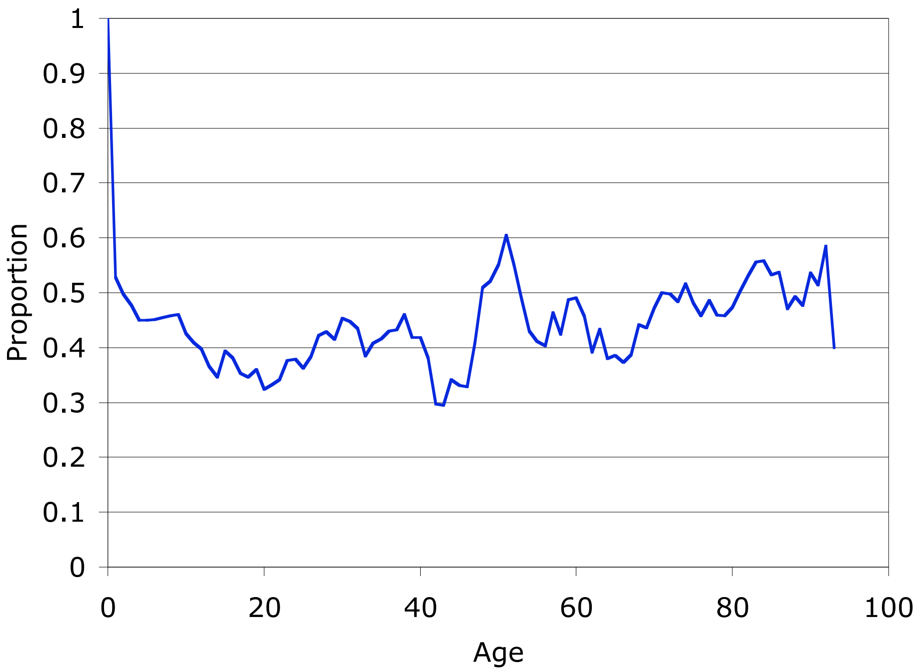

Figure 2.26
Proportion of pedestrian hospital separations missing from TARS, 1990 – 2005, by age of casualty

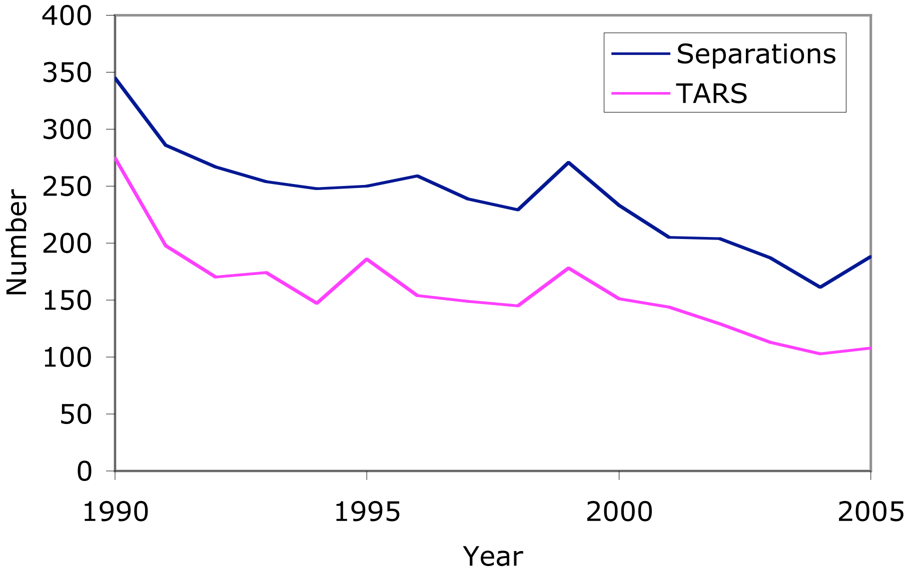

Figure 2.27
Trends in pedestrian hospital separations and casualties coded as hospital admission in TARS, 1990 - 2005

2.4 Alcohol use amongst pedestrians and drivers in crashes

Ascertaining the prevalence of alcohol use in pedestrian casualty crashes is problematic: even though there is a variable in TARS, it is inconsistently used. Figure 2.28 shows time series data for blood alcohol concentration (BAC) readings recorded in TARS for fatally injured pedestrians. For recent years, the BAC data is relatively complete, and in years 2003, 2004 and 2005, a third of all pedestrians killed had a BAC greater than or equal to 0.05 g/l. Forty percent of the pedestrians 18 or older who were killed had a BAC greater than or equal to 0.05 g/l.

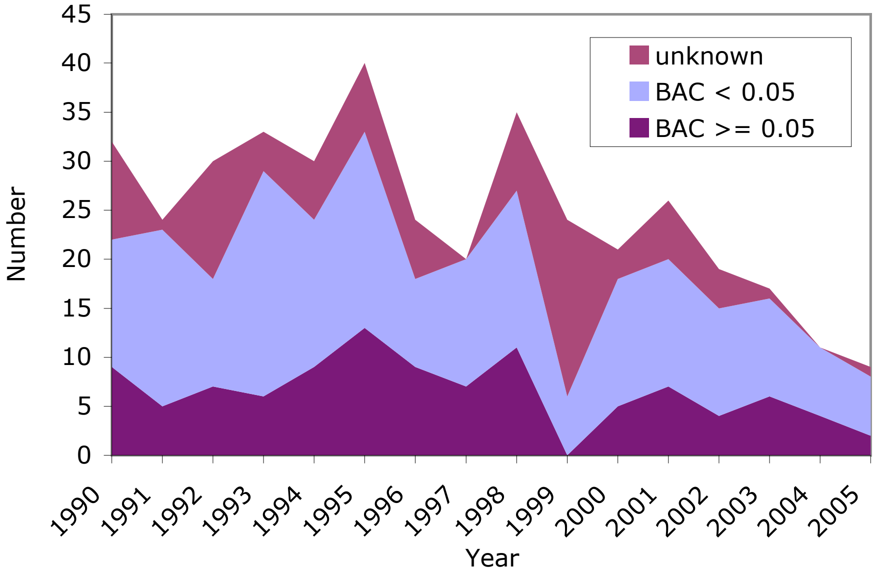

Figure 2.28
Alcohol use among fatally injured pedestrians in South Australia, 1990-2005 (Source: TARS)

According to Figure 2.29, alcohol use among all pedestrian casualties appears to be lower than for the fatally injured group. While the alcohol level for the majority of casualties is not recorded in TARS, we expect that the alcohol use for the unknown group to be lower than alcohol use amongst the casualties with known BACs.

Alcohol use among drivers in pedestrian collisions is more difficult to determine. As is evident in Figure 2.30, alcohol use among drivers in fatal collisions is poorly recorded in TARS, even though, as we understand, it is routine procedure that attending police measure the BAC of drivers in such cases.

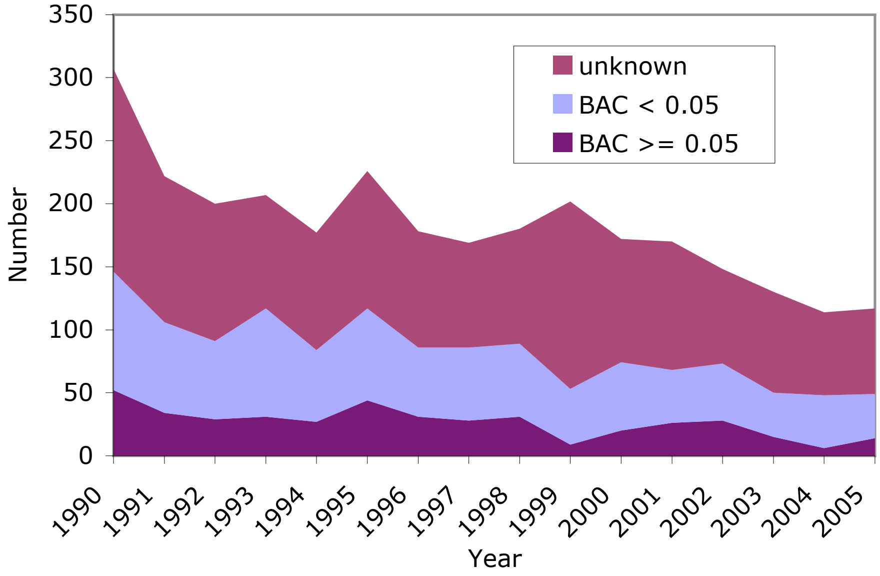

Figure 2.29
Alcohol use among pedestrian casualties in South Australia, 1990-2005 (Source: TARS)

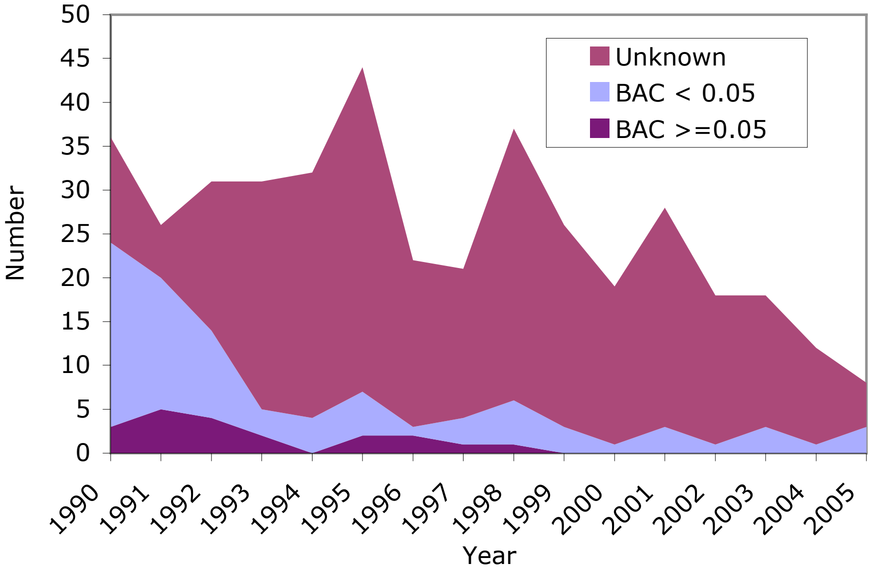

Figure 2.30
Alcohol use among drivers involved in fatal pedestrian crashes in South Australia, 1990-2005 (Source: TARS)

2.5 Discussion

The number of young pedestrian casualties has decreased in recent years with the number of pedestrian casualties under 21 years of age falling by more than 50% since 1990. Smaller percentage declines are apparent for pedestrians aged between 30 and 35 and over 60, with the remainder (a minority group amongst pedestrian casualties) changing little over time. In effect, the age distribution of pedestrian casualties has flattened considerably since 1981.

By considering three separate periods between 1981 and 2005 we made some interesting observations: the period between 1981 and 1991 produced marked reductions in the population-based rate of pedestrian casualties aged less than 21 and over 50. The change in the number of casualties was not strongly determined by shifts in the age composition of the population. Between 1991 and 2002, changes in the number of pedestrian casualties appear to correlate better with changes in the population, but continued declines for the young and older pedestrians are still apparent. Over the entire period 1981-2002, the rate of casualties for pedestrians of middle age (35 – 60) was relatively constant and, if anything, tended to increase in the latter decade. Recent trends are somewhat different; indications are that the decline in pedestrian casualties since 2002 is uniformly spread over the age distribution. Although tentative, this uniform reduction may reflect the effect of reduced travelling speeds following the introduction of the default urban speed limit of 50 km/h.

The overall decline in pedestrian crash numbers has resulted largely from declines in pedestrian casualties under 20 years of age and is not explained by any decline in the population in this age group. Instead we suspect that changes in the amount of walking may be the best explanation, although there is little data to prove this directly. Instead the effect of exposure is suggested by the differential declines between age groups. An alternative explanation is a reduction in the per-trip risk of being involved in a pedestrian collision noting that this reduction has not been uniform over different age groups (suggesting that neither drivers, vehicles nor infrastructure can be credited with being the major factor in the reduction in risk), and has been most pronounced amongst teenagers.

Supporting the importance of exposure in explaining changes in the number of pedestrian casualties is the ratio of pedestrian to driver casualties. This ratio has declined linearly since 1990. In the UK, the ratio of walking exposure to driving exposure has declined linearly over the same period and if this indicates recent trends common to motorised countries, it might explain the trend in South Australia. Better exposure data in South Australia would be required to investigate this further.

Health data reveals that the number of pedestrian casualties may be underestimated in the Traffic Accident Reporting System, but this underestimation may be largely a miscoding error (with admissions being recorded as treated). Hospital separation data suggests that about 40% of admissions are either missing or being miscoded in TARS.

Alcohol is clearly a major factor in pedestrian fatalities. Forty percent of fatally injured pedestrians over the age of 18 had blood alcohol concentrations higher than 0.05 g/l. The involvement of alcohol for drivers is less clear in these crashes as the data is largely missing from the Traffic Accident Reporting System.

3 Times and locations of crashes

Figure 3.1 shows the hourly rate of pedestrian casualties by the time of the day. The two lines represent the hourly rates for weekdays and weekends. The shaded areas cover the hours between 8 am and 9 am, and 3 pm and 5 pm. During the week, these hours are the peak periods for pedestrian crashes and the rate of collisions during this period is nearly double that of adjacent hours and is significantly higher than for the same hours on the weekends.

On the weekends however, the rate of pedestrian casualty crashes between the hours of midnight and 5 am is much higher than the equivalent hours during the week.

It is likely that these patterns (the differences between weekdays and weekends, and the peaks evident in the weekday data) reflect patterns in the volumes of traffic and pedestrian traffic and alcohol usage.

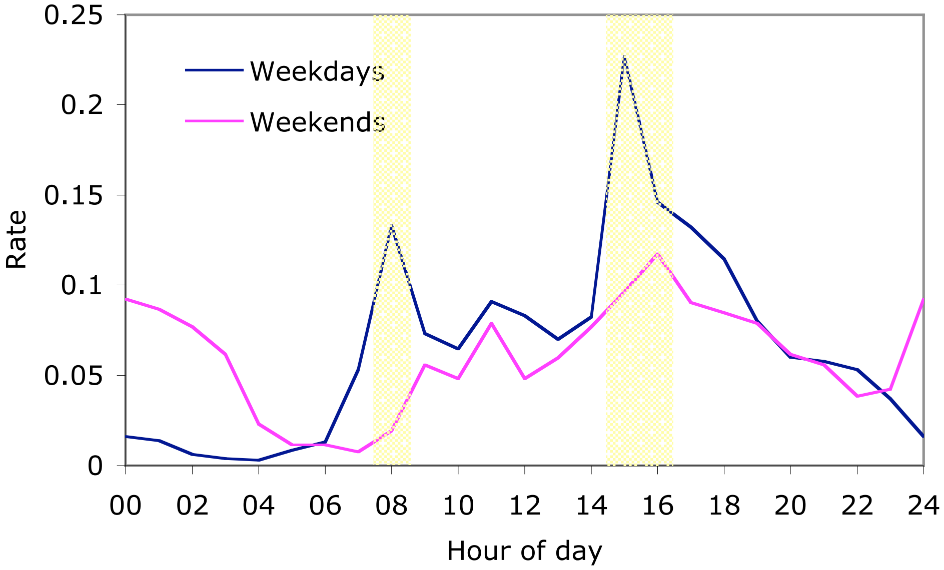

Figure 3.1
Hourly rate of pedestrian casualties (treated at hospital or more severe)
in South Australia by hour of day, 2000-2006

Figures on the next 3 pages show the locations of pedestrian crashes in metropolitan Adelaide that occurred between the years 2000-2006 inclusive.

Figure 3.2 shows a map of serious injury and fatal crashes in the greater Adelaide, and Figure 3.3 shows the location of fatal crashes only. Both maps differentiate crashes by the speed limit of the roads upon which each crash occurred. Note that the speed limit indicated is that which applied after March 2003 and so most of the 50 km/h roads indicated may have had a speed limit of 60 km/h at the time of the crash.

Figure 3.2 shows that the majority of serious and fatal crashes outside the central business district occurred on roads that now have a speed limit of 60 km/h. Of note are the very few fatal accidents that occurred on 50 km/h roads (Figure 3.3). This is probably a reflection not only of the lower speeds on those roads but the lower volumes of both vehicle and pedestrian traffic.

The central business district is an exception to this where pedestrians and traffic exist in high volumes. Significant numbers of crashes occur in the CBD, but very few are fatal.

Figure 3.4 shows the locations of pedestrian crashes in the CBD: the largest concentration of crashes is around North Terrace, Grenfell Street and Currie Street, King William Street, and Pulteney Street, probably reflecting the areas of highest pedestrian traffic.

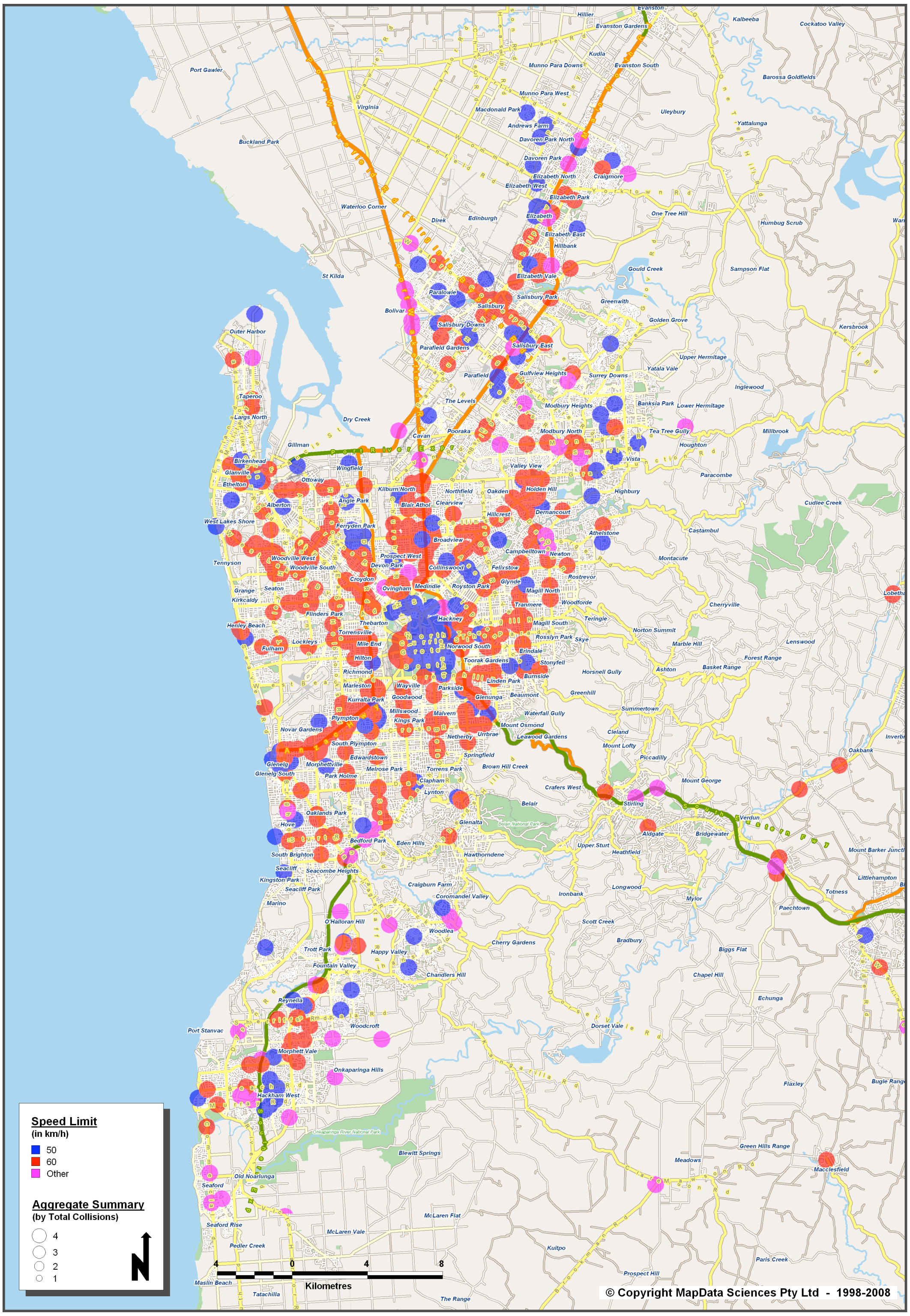

Figure 3.2
Serious injury and fatal pedestrian crashes, greater Adelaide area 2000-2006 by speed limit

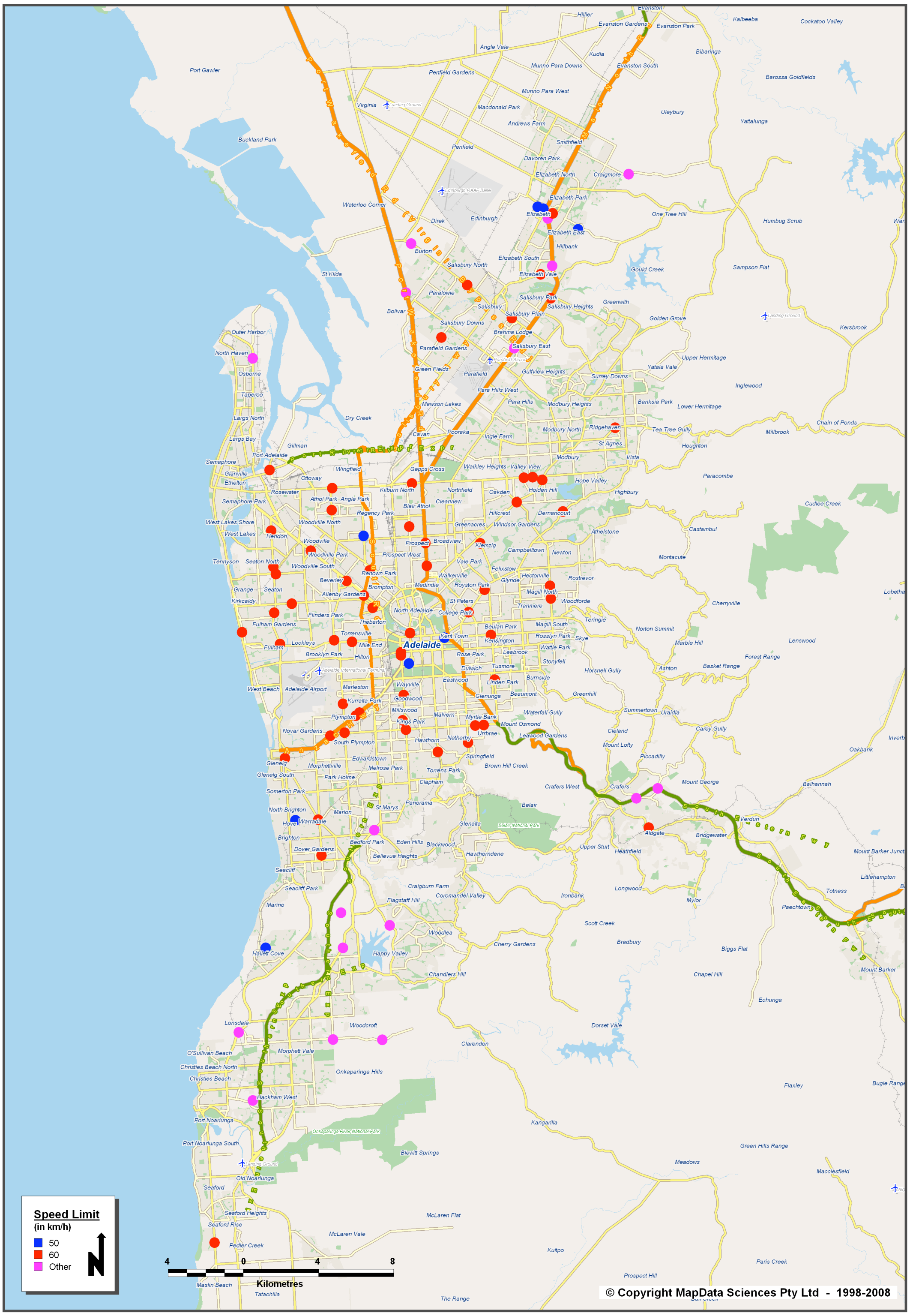

Figure 3.3
Fatal pedestrian crashes, greater Adelaide area 2000-2006 by speed limit

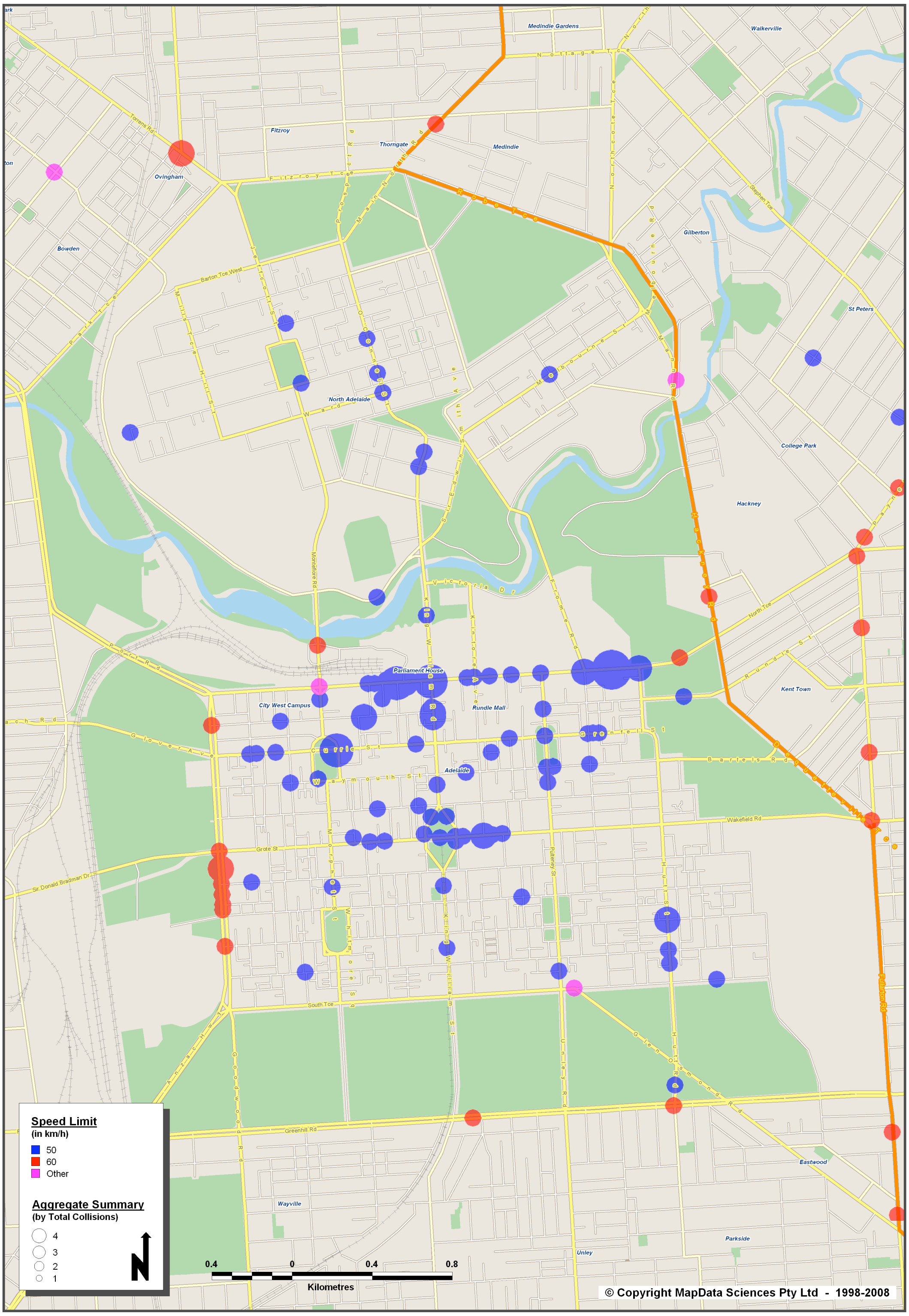

Figure 3.4
Serious injury and fatal pedestrian crashes, Adelaide CBD and North Adelaide 2000-2006, by speed limit

4 The effect of the introduction of 50 km/h speed limits on pedestrian crashes in South Australia

On 1 March 2003 the default urban speed limit in South Australia was reduced from 60 km/h to 50 km/h, with expectations that the number of crashes and casualties would be reduced. The implementation of the lowered limit is described in detail in Kloeden, Woolley and McLean (2004), but in summary:

- The default urban speed limit was reduced to 50 km/h
- Urban arterial roads were signed with a 60 km/h limit
- Local government authorities nominated roads to be signed with a 60km/h limit, with approval at the discretion of the South Australian Department of Transport and Urban Planning (now the Department for Transport, Energy and Infrastructure – DTEI).

A previous evaluation of the change in the speed limit showed positive results: travelling speeds fell on 50 km/h roads by 2.3 km/h and casualty crashes and casualties fell by 20% and 24%. It was also noted that falls in speeds and casualties occurred on roads where the limit remained at 60 km/h: speeds fell by 0.9 km/h and casualty crashes and casualties fell by 5% and 7%. While the change in speeds on 60 km/h roads was less than on 50 km/h streets, it accounted for more than 50% of the savings in casualty costs because the incidence of casualty crashes on arterial roads is higher than on local streets.

4.1 Changes in vehicle speeds

The 60 km/h speed limit on urban arterial roads in South Australia was largely retained after the introduction of the default 50 km/h urban limit. Figures 4.1 to 4.3 show the results of a survey of freely chosen travelling speeds on a selection of arterial, collector and local roads in the Adelaide metropolitan area before and after the change in speed limit (see Kloeden, Wolley and McLean, 2004 for details). The decline in speeds on collector and local roads is clear, but a decline on arterial roads is also apparent. Free travelling speeds on roads changed to 50 km/h declined by 2.2 km/h, and on arterial roads by 0.7 km/h.

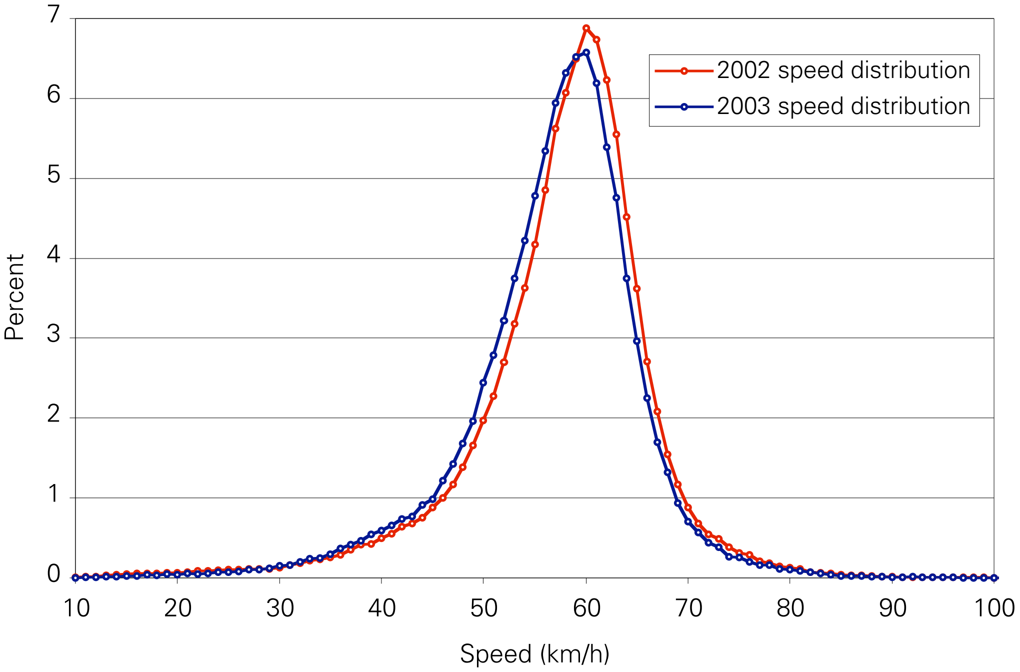

Figure 4.1
Distribution of free travelling speeds on arterial roads before (2002)
and after (2003) the introduction of the 50 km/h default urban speed limit
(arterial roads retained a 60 km/h speed limit) (From Kloeden, Woolley and McLean, 2004)

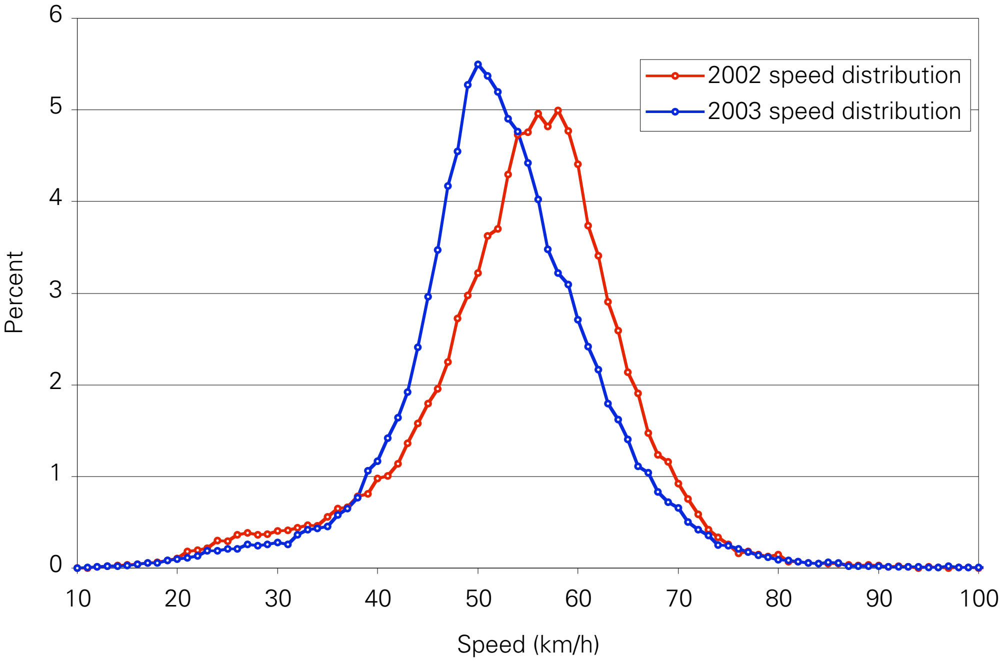

Figure 4.2
Distribution of free travelling speeds on collector roads before (2002) and after (2003) the introduction
of the 50 km/h default urban speed limit (From Kloeden, Woolley and McLean, 2004)

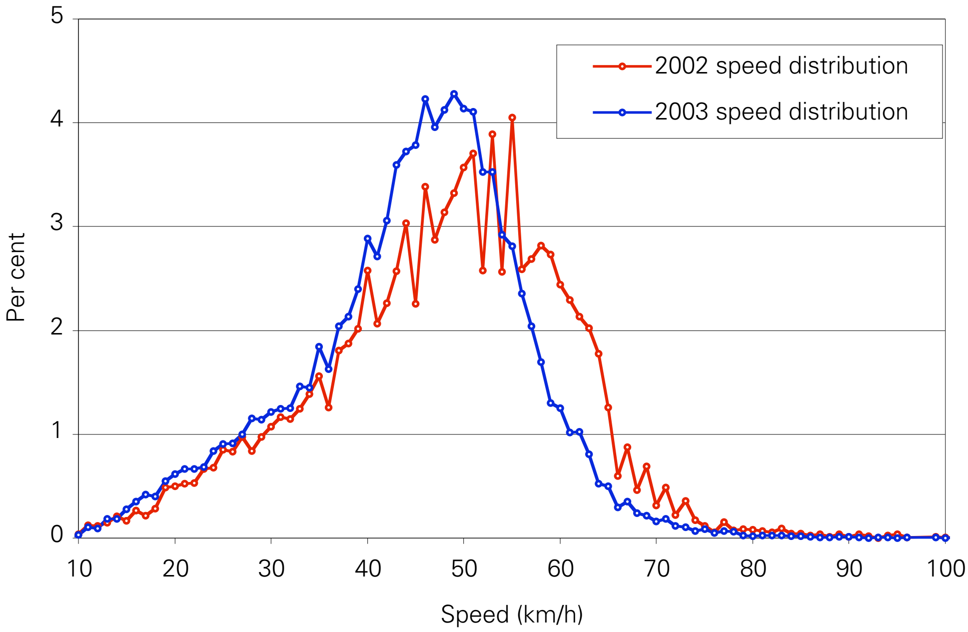

Figure 4.3
Distribution of free travelling speeds on urban local roads before (2002) and after (2003) the introduction of the 50 km/h default urban speed limit (From Kloeden, Woolley and McLean, 2004)

4.2 Pedestrian casualty crashes on 50 km/h and 60 km/h roads

4.2.1 Identification of 50 km/h roads

It is important to note that, at the time of writing, no definitive list of roads that were changed to 50 km/h limit on the 1st of March, 2003, exists, nor does a list of roads that remained at 60 km/h. A technique for identifying 50 km/h roads was described in Kloeden, Woolley and McLean (2004). The same method has been employed in this study.

The following logic was used to classify crashes as being on one of three road types: those roads that changed from 60 to 50 km/h; those roads that remained at 60; or those roads with some other limit:

- We obtained lists of roads remaining at 60 km/h from DTEI and local councils and created a list of those roads along with their TARS road number.
- If the police-recorded speed limit was 50 or 60 km/h and the crash occurred on a road on our list of 60 roads or at an intersection where at least one of the roads was on our list of 60 roads then the crash was classified as being on a road that remained at 60
- If the police-recorded speed limit was 50 or 60 km/h and the crash occurred on a road not on our list of 60 roads or at an intersection where neither of the roads was on our list of 60 roads then the crash was classified as being on a road that changed from 60 to 50
- In all other cases the crash was classified as being on an “other limit” road
- In addition, in all cases where the crash was recorded as happening in a car park, it was classified as being on an “other limit” road even if it matched the above criteria.

While this was not an infallible method for classifying the crashes, it was the best method we could use given the available data and should approximate the real situation very closely.

4.2.2 Trends in crashes on 50 km/h and 60 km/h roads

Figure 4.4 shows the number of pedestrian casualty crashes (those treated or admitted to hospital and fatalities) occurring yearly on South Australian roads, disaggregated by the applicable speed limit from the 1st of March, 2003 (as defined above). Each data point indicates the numbers of crashes occurring from the 1st of March to the end of February the following year.

To analyse the effect of the change in the default urban speed limit, a model was created to describe the crash data. The data in Figure 4.4 are replotted in Figure 4.5 on a logarithmic scale. A constant percentage reduction from one year to another corresponds to a straight line on such a scale, and is a useful scale for modelling crash reductions where the numbers of crashes from year to year may include a constant percentage change.

The model fitted to the data had three parameters of interest: the trend (a constant percentage change from year to year), a step function for the 50 km/h roads describing the period before and after the change in the default urban speed limit, and a step function for the 60 km/h roads. The inclusion of separate step functions for 50 km/h roads and 60 km/h roads allows the effect of the change in speed limit to be estimated separately for each type of road. An additional variable was defined to allow for inherent differences in the crash numbers between 50 km/h and 60 km/h roads.

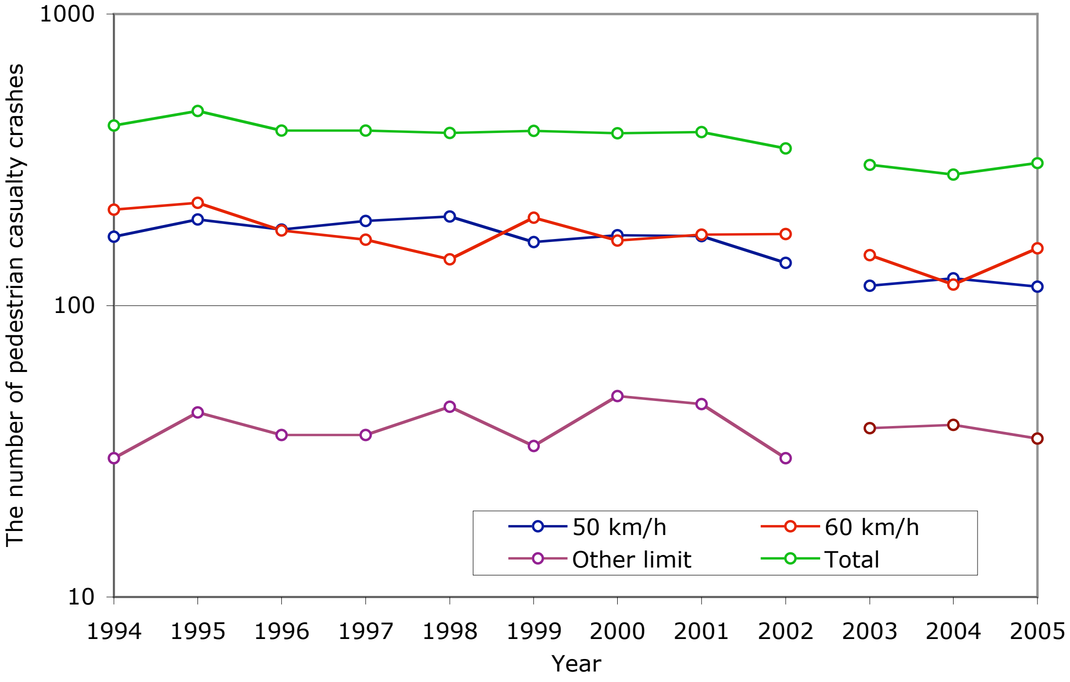

Figure 4.4
Number of casualty (treated +) pedestrian crashes (March to December for the given year plus the January to February numbers for the following year) on roads in South Australia (Source: TARS data)

The values of the parameters of interest were estimated by performing a logistic regression: crashes on 50 km/h and 60 km/h roads were entered separately and regressed on the variables YEAR, STEP_50, STEP_60 and R50_60 using the statistical computer package SPSS.

Some variations on this analysis were also performed:

- A similar analysis on the data relating only to more serious casualties (hospital admissions and fatalities) was performed
- Data restricted to the Adelaide statistical region and to the CBD were also analysed.
- For each set of data, a model was created which includes a single step function to estimate a common effect of the speed limit change on both sets of roads, and a function that allows a differential effect to be estimated between 50 km/h and 60 km/h roads. This model examines whether the change in the DUSL had a general effect on all roads, and whether the effects were significantly different on 50 km/h and 60 km/h roads.

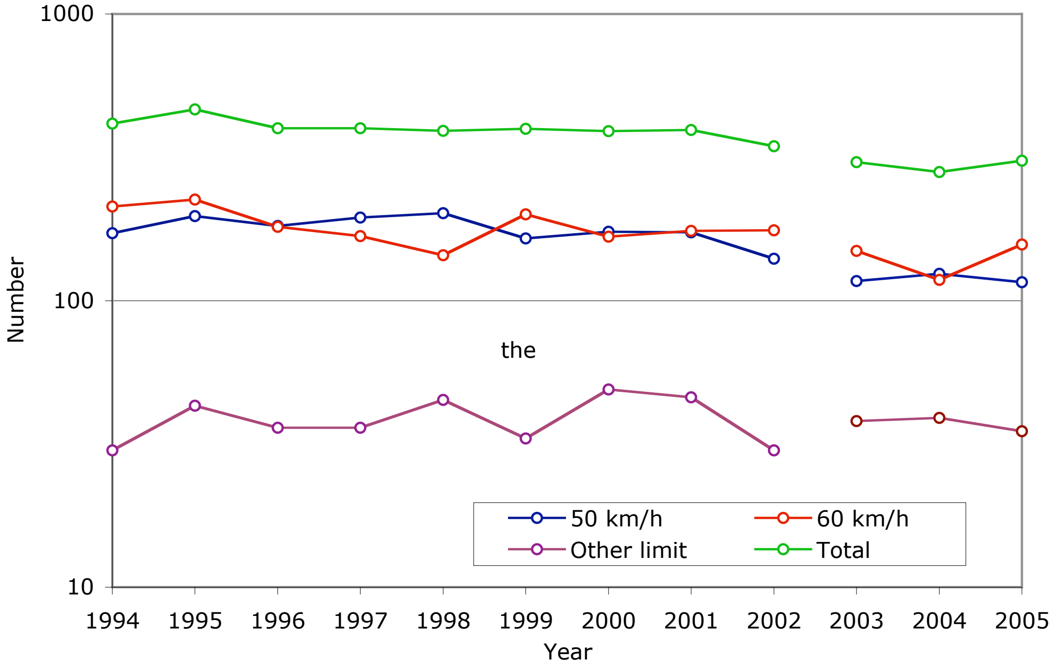

Figure 4.5
The data plotted in Figure 4.4, but plotted on a logarithmic scale

4.3 Results for 60 km/h roads and 50 km/h roads in South Australia

The results of the regression yielded a yearly decline in the number of pedestrian casualty crashes on 50 and 60 km/h roads of 2.4% per year. In addition to this was a steep reduction in the number of crashes on 50 km/h roads, corresponding to the change in speed limit, of 26%. A decline of 12% was seen on 60 km/h roads, corresponding to the change in speed limit. The results of variations on this analysis are shown in Table 4.1.

The range of estimated effects of the introduction of the 50 km/h limit range between a 26% reduction and a 36% reduction in pedestrian crashes (depending on the location and severity considered, and considering only statistically significant results). Non-significant reductions in crashes on 60 km/h roads of 9% to 15% were also observed.

Table 4.1
Estimates of the effect on pedestrian crashes
of the change in the default urban speed limit from 60 km/h to 50 km/h

Data	Yearly change	Percentage change in crashes on 50 km/h roads corresponding with the change in the GUSL	Percentage change in crashes on 60 km/h roads corresponding with the change in the DUSL
SA casualties	-2.4*	-26*	-12
Adelaide casualties	-2.0*	-26*	-11
CBD casualties (1)	-1.2*	-29*	n.a
SA admissions and fatalities	-4.2*	-36*	-15
Adelaide admissions and fatalities	-4.9*	-31*	-9
CBD admissions and fatalities (1)	-4.4	-39	n.a.

* Statistically significant $p < 0.05$

(1) Roads currently subject to a 50 km/h limit only

4.4 The effect of 50 km/h in the Adelaide Central Business District

Estimating the effect of the introduction of the 50 km/h limit throughout the Adelaide CBD is of particular interest as the CBD contains a high concentration of pedestrian traffic, and nearly the entire street network was subject to the new limit. Figure 4.6 shows the number of casualties on roads in the CBD now subject to a 50 km/h speed limit. It should be noted that this excludes West Terrace and sections of Morphett Road, which was signed with a 60 km/h limit following the 1st of March, 2003.

The data for the CBD show much higher variability than the data for the whole of the State (Figure 4.4), which is to be expected when considering a more restricted set of roads. The very small numbers of roads and crashes on 60 km/h roads in the CBD does not allow us to compare reductions on 60 km/h roads and 50 km/h roads. Data for the CBD only are shown in Figure 4.6. Considering crashes on the 50 km/h roads only yielded a 29% reduction in all casualties associated with the change in the speed limit, against a background average decline of around 1% per annum (Table 4.1). However, it may be noted that no trend consistent with a constant decline over the entire period in question is evident in the data in Figure 4.6 for the CBD. Instead, it might be noted that the average number of casualty crashes is 36% lower in the ‘after’ period than the average of the preceding nine years, and that there have been no fatalities on 50 km/h roads in the CBD recorded since the introduction of the limit. There have been two fatalities on roads in the CBD remaining at 60 km/h since the 1st of March 2003.

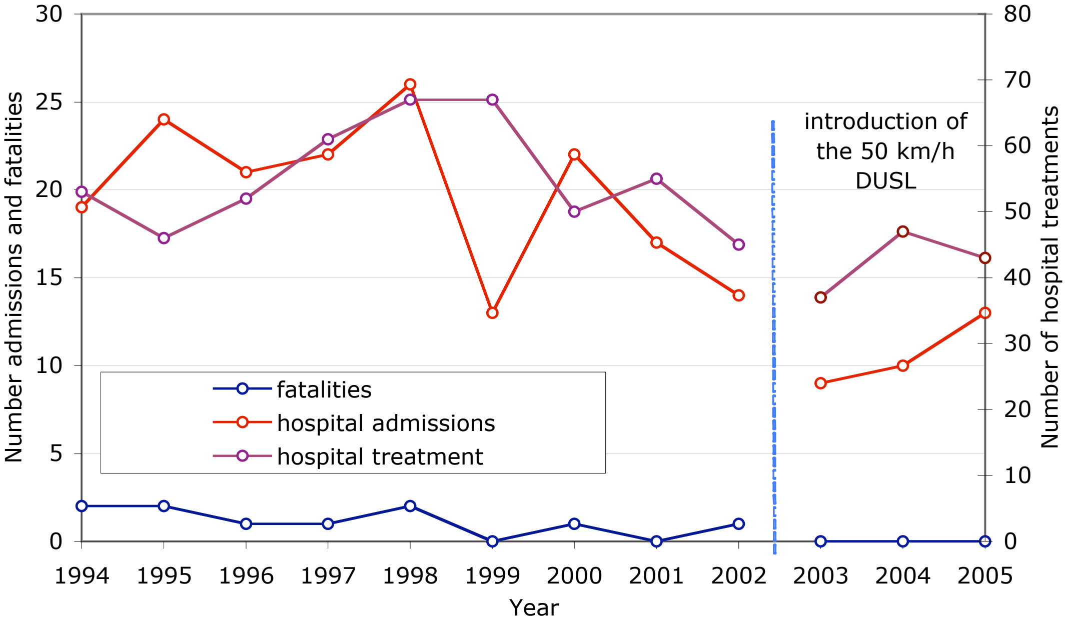

Figure 4.6
Pedestrian casualties on 50 km/h roads in the central business district of Adelaide.
(Yearly figures are to from March to February of the following year,
to synchronise with the DUSL change; source: TARS data).

4.5 A comparison between observed effects of the introduction of the 50 km/h DUSL and predictions made in Anderson et al., 1997

In 1997, the Road Accident Research Unit (RARU) estimated the effect that a reduction in vehicle travelling speeds would have on fatal pedestrian accidents (Anderson et al., 1997). That analysis used the reconstruction of 176 fatal pedestrian crashes that had occurred in the Adelaide metropolitan area in the 1980s and 1990s and that had been investigated by RARU.

Through the reconstruction methodology, the impact speed in each case was expressed as a function of the travelling speed and other variables associated with the collision. Holding these other variables constant, the effect of the travelling speed on the impact speed could be studied, and different travelling speed scenarios were examined.

To estimate the effect on the number of fatalities, a relationship between impact speed and the probability of death was developed from other published data. This allowed the effect on the number of fatalities of any particular scenario of altered travelling speeds to be estimated.

Several scenarios were simulated including uniform reductions in travelling speed (5 km/h, 10 km/h) and elimination of illegal speeding. Relevant to the effect of reduced speed limits was an estimate of the effect of a reduction in the general urban speed limit from 60 km/h to 50 km/h.

The assumption used in this scenario was that any driver who had been travelling between 50 km/h and 60 km/h in the fatal crash would observe the reduced limit and travel at 50 km/h. Those drivers who were exceeding the speed limit would reduce their speed by 10 km/h. With these new travel speeds, each crash was 're-played' to estimate a new impact speed and a new probability of death. The study estimated that 30% of fatal crashes on 60 km/h roads would have been either prevented altogether (14%) or reduced in severity

(16%). This estimate falls in the middle of estimates of the actual effect presented in Table 4.1.

In the 1997 paper, the mechanism for such a large reduction was explained by the relationship between travelling and impact speeds: The speed of a vehicle undergoing braking drops with the square of the distance so that a greater proportion of speed is lost in the last few metres of braking than in the first few metres. This phenomenon is illustrated in Figure 4.7, reproduced from Anderson et al., 1997.

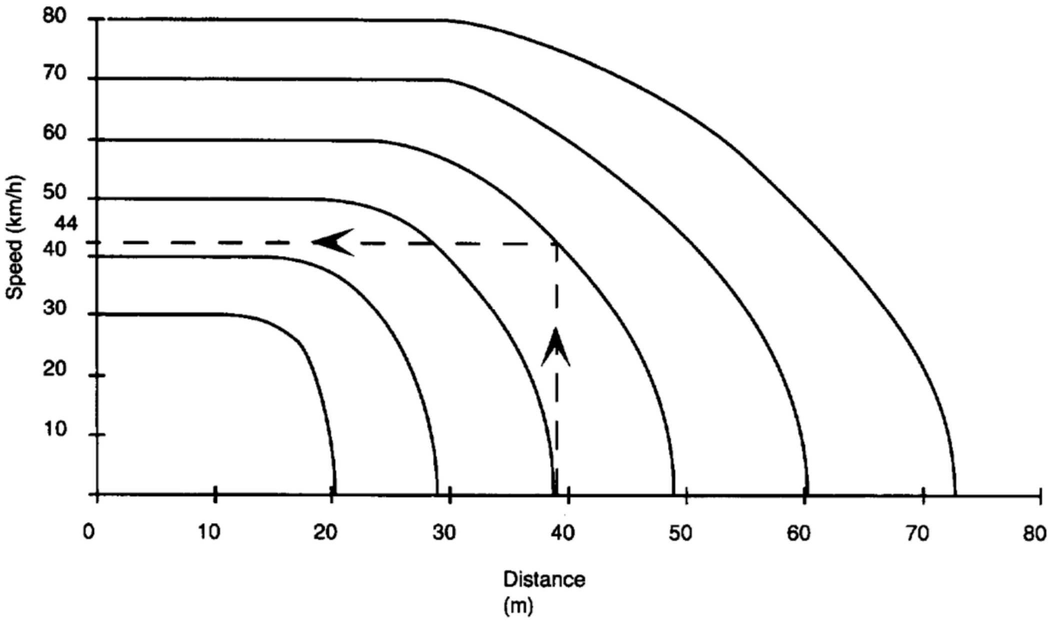

Figure 4.7
Speed versus distance in emergency braking (from Anderson et al., 1997)

Quoting from Anderson et al, 1997:

> Figure [4.7] shows the relationship between initial speed and stopping distance. The curves relating speed to distance commence in each case with a horizontal straight section which represents the distance covered during the driver's reaction time, with the vehicle proceeding straight ahead at the initial travelling speed. Once braking commences, the speed of the vehicle decreases with distance travelled in the manner shown, quite gradually at first and then decreasing more and more rapidly. It can be seen in Figure [4.7] that, from an initial speed of 80 km/h, the vehicle travels about 45 metres during the first 10 km/h decrease in speed, whereas the vehicle travels less than one metre during the last 10 km/h of speed reduction before the vehicle stops.
>
> The effect on impact speed of a 10 km/h difference in travelling speeds can be seen in the following example, which is indicated by the intercept lines in Figure 6. Consider two cars travelling side by side at a given instant, one car travelling at 50 km/h and the other overtaking at 60 km/h. Suppose that a child runs onto the road at a point just beyond that at which the car travelling at 50 km/h can stop. The other car will still be travelling at 44 km/h at that point, a collision speed at which a pedestrian has more than a 50 per cent probability of being fatally injured.

The consistency between the estimate of the effect of a reduced speed limit and actual experience suggests a possible mechanism by which crashes have been reduced in Adelaide since the introduction of the 50 km/h speed limit.

4.6 Discussion

It appears that the change to 50 km/h on some roads in South Australia has had a substantial effect on the number of pedestrian casualty crashes. The change coincides with a 36% reduction of serious pedestrian casualty crashes on 50 km/h roads.

To interpret the meaningfulness of the reduction requires us to make some assumptions, about which we have reason to be uncertain.

- On the one hand we might not expect pedestrian crashes on roads that remained with a limit of 60 km/h to be affected by a reduction in speed limits on a separate set of roads. Under this assumption, the effect of the reduction in the limit lies in the range of 14 – 22%, depending on the geographic areas included and level of injury severity being considered. (It is the effect on 50 km/h roads minus the effect on 60 km/h roads.) Analyses where the test was for a differential effect on each set of roads, found that the net effect on 50 km/h roads was not statistically significant.
- On the other hand, we noted reduction in both vehicle speeds and crashes on 60 km/h roads corresponding with the change in the default urban speed limit (Kloeden, Woolley and McLean, 2004). These reductions call into question the notion that 60 km/h roads were unaffected by the change in limits, and therefore their appropriateness as a set of 'control' roads against which the effect on 50 km/h roads might be assessed. In considering the appropriateness of the assumption, we should bear in mind that roads do not have crashes – drivers do; those drivers will use all parts of the road network, and so some general effect on behaviour on 60 km/h roads is plausible. We might therefore conclude that the effect of the change in limit on 50 km/h roads was substantial and a statistically significant departure from the underlying trend in crash numbers, and there is some evidence that the effect 'leaked' onto roads that remained at 60 km/h.

This analysis is an example of an analysis where the uncertainty about the assumptions is greater than the statistical uncertainty, and as a result we are limited in making firm conclusions about the causality of the speed limit reduction on the number of crashes. However the effect observed is consistent with the effect of reductions in observed vehicle speeds and predictions from the analysis of actual crashes. And so on balance, this consistency leads us to believe that the observed effect is real and substantial.

5 Data from the in-depth investigation of pedestrian crashes

This section uses two recent sets of in-depth crash investigation data to describe the circumstances of pedestrian crashes to a level of detail that is not able to be gleaned from routinely collected, police reported crash data. By coincidence, each set of data contains almost identical numbers of collisions. In most tables presented in this section, both sets of data have been combined as the characteristics of each set of data did not vary greatly.

5.1 The data

5.1.1 Vehicle Design and Operation for Pedestrian Protection 1998-2000 (P series)

Between 1998 and 2000, 77 pedestrian accidents were investigated at the scene for the Federal Department of Transport and Regional Services. Notification of accidents was by means of monitoring emergency radio frequencies, and via a pager alert from the South Australian Ambulance Service. In some fatal cases, local media provided an alert that the accident had taken place, and the investigation was begun by attendance at the autopsy of the pedestrian.

The main aim of this project was to collect information on the interaction between the pedestrian and the vehicles. Consequently, the focus of the data collection was on items of information that would allow an estimation of the vehicle travel and impact speeds, contacts between the pedestrian and the vehicle, injuries sustained in the accident and the likely source of those injuries. Additionally, road and traffic factors were also recorded. The accident data has been submitted to the Federal Department of Transport and Regional Services (Anderson et al., 2000).

Four accidents involved two pedestrians, and one accident involved two vehicles, giving a total of 81 pedestrians and 78 vehicles in the series.

5.1.2 In depth investigation of crashes in metropolitan Adelaide, 2002-2005 (M series)

A similar methodology was applied to the collection of pedestrian crashes in the Adelaide metropolitan area between 2002 and 2005. All types of crashes occurring were investigated for the Motor Accident Commission of South Australia and the Department for Transport, Energy and Infrastructure. The pedestrian cases were also the subject of detailed modelling and reconstruction for Mitsubishi Motors Corporation in Japan.

Seventy seven crashes were investigated, coincidently the same number as the earlier study. One case involved two pedestrians and one involved three. Three cases involved two vehicles, giving a total of 80 pedestrians and 80 vehicles in the series.

5.2 Characteristics of the data

5.2.1 Time of day and day of week

Figures 5.1 and 5.2 present the distribution by time-of-day and day-of-week of the pedestrian crashes that we investigated and all pedestrian crashes reported to the police in the Adelaide area between 1998-2005. It may be noted that very few crashes were sampled on weekends or from early evening to the early morning. The bias in our sample toward day time crashes is apparent, with crashes outside of business hours and weekends being under-represented.

The highest hourly frequency for pedestrian collisions was from 3 to 4 pm (Figure 5.1), which includes the time at which school children finish school for the day. Twenty seven of the 38 pedestrians involved in the collisions that we investigated during that hour were under 20 years of age. In comparison, seven of the 23 pedestrians involved in collisions between 4 and 5 pm were under 20 years of age.

In the majority of night time collisions that we investigated the pedestrian was fatally injured. This does not necessarily mean that night time collisions are more severe but rather that the specialist police unit that investigates fatal crashes had marked up the scene of the crash, which made it possible for us to commence an investigation on the following day. In cases in which there was no likelihood that the pedestrian's injuries would be dangerous to life we usually had to rely on our attendance at the scene immediately after the crash to record the information that we needed to determine what had happened immediately before and during the crash.

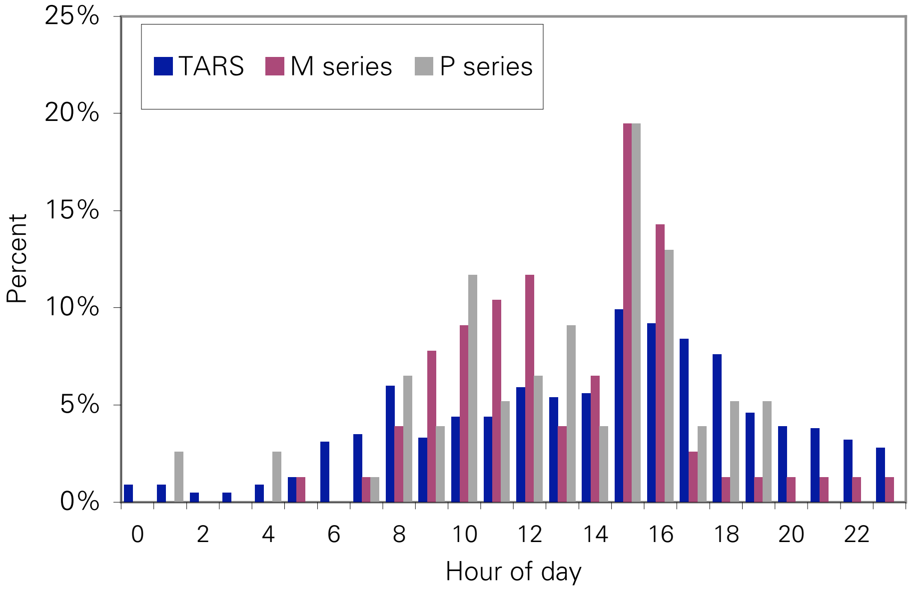

Figure 5.1
Distribution of crashes by time of day: all pedestrian crashes in the study area (1998 –2005) and the sample of crashes in the P series and the M series of crashes (Source: TARS)

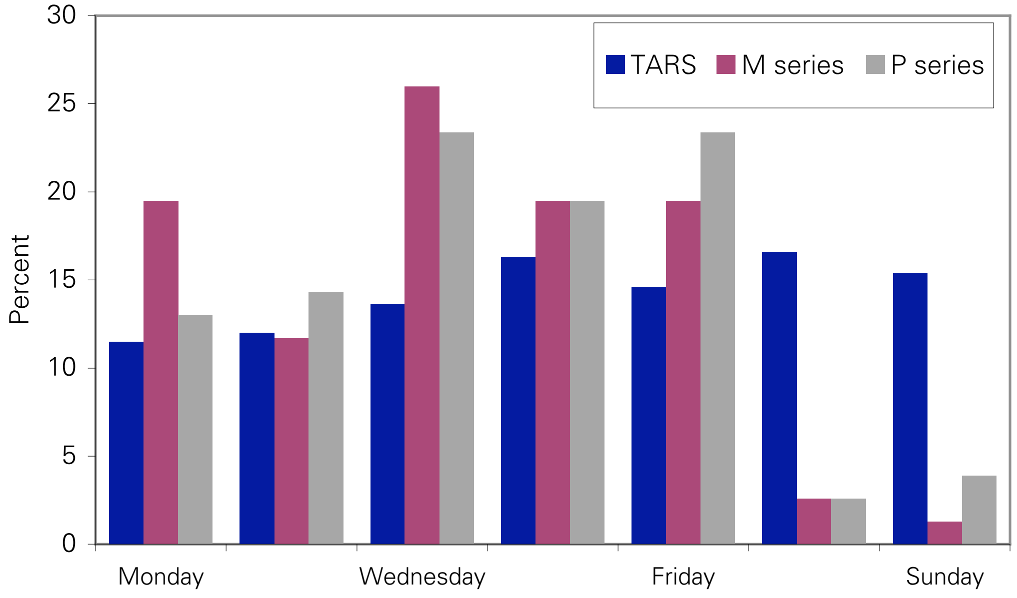

Figure 5.2
Distribution of crashes by day of week: all pedestrian crashes in the study area (1998 –2005) and the sample of crashes in the P series and the M series of crashes (Source: TARS)

5.2.2 Lighting and weather conditions

As indicated by the time of day information in Table 5.1, most of the cases studied occurred in daylight. Of those that occurred at night, the scene of the crash was illuminated, sometimes poorly, by street lighting.

The weather conditions were typical of the Adelaide area, with relatively few rainy days (Table 5.1)

Table 5.1
Lighting and weather conditions: P and M series combined

Lighting Conditions	Weather Conditions		
	Dry / Fine	Rain	Total
Daylight	117	13	130
Dusk	3	1	4
Night (street lighting)	16	4	20
Total	136	18	154

5.2.3 Road, site and infrastructure characteristics

The road environment in the study area comprised mainly wide straight streets and major roads, many of the latter having a speed limit of 60 km/h.

In March 2003, the default urban speed limit in South Australia was reduced to 50 km/h rather than the previously existing 60 km/h. The default limit applies unless a road is signed at a different, usually higher, speed limit. Most main roads have retained a limit of 60 km/h and the majority of the pedestrian collisions outside the Adelaide CBD occur on those roads. A speed limit of 25 km/h applies adjacent to schools when children are present. Hence the P series, which was collected prior to 2003, contains only crashes on 60 km/h roads, whereas the M series, which was collected both before and after the speed limit change has a proportion of crashes that occurred on 50 km/h roads. The speed limit of the roads on which the crashes investigated occurred is given in Table 5.2.

Table 5.2
Speed limit of road

Speed Limit (km/h)	P series	M series	Total number of cases
25		1	1
50		24	24
60	74	50	124
70		1	1
80	2	1	3
100	1		1
Total	77	77	154

Table 5.3 shows the location of crashes relative to the nearest designated crossing facility. About one quarter of crashes occurred on roads where crossing facilities would not be expected (rural roads or residential streets). Of the remaining crashes, a quarter occurred at a designated crossing facility. A further 20-25% of crashes occurred within 50 metres of a crossing facility.

Table 5.3
Distance of impact point from a pedestrian crossing facility

Distance from crossing (metres)	P series		M series	
At crossing	14	(24%)	12	(20%)
1-10	2	(3%)	2	(3%)
11-20	0	(0%)	1	(2%)
21-30	2	(3%)	4	(7%)
31-40	3	(5%)	1	(2%)
41-50	8	(14%)	3	(5%)
51-60	4	(7%)	1	(2%)
61-70	5	(9%)	2	(3%)
71-80	3	(5%)	4	(7%)
81-90	2	(3%)	3	(5%)
91-100	3	(5%)	1	(2%)
101-150	1	(2%)	5	(8%)
151-200	4	(7%)	6	(10%)
201-250	2	(3%)	1	(2%)
251-300	2	(3%)	3	(5%)
301-400	3	(5%)	1	(2%)
400+	0	(0%)	9	(15%)
N/A[1]	19	-	18	-
Total	77	(100%)	77	(100%)

1. "N/A" in this context means that the environment was not one where one would normally expect to see a crossing facility: e.g a residential street or a rural road, or where the collision took place off the roadway

Table 5.4 shows that the typical pedestrian collision occurs with no visual obstruction (external to the vehicle) between the pedestrian and the driver. In around one quarter of collisions there was some external visual obstruction, usually other vehicles either parked or in the traffic stream.

Table 5.4
Visual obstruction before the collision

Visual obstruction	P series		M series	
No obstruction	50	(67%)	48	(70%)
Parked vehicle(s)	6	(8%)	6	(8%)
Stationary vehicle(s) in traffic	15	(20%)	9	(13%)
Moving traffic	1	(1%)	0	(0%)
Sun	3	(4%)	4	(6%)
Infrastructure	0	(0%)	2	(3%)
Unknown	2	(-)	0	(-)
Total	77	(100%)	69	(100%)

5.2.4 Age and sex of the driver of the vehicle

Thirty six percent of the drivers involved in these pedestrian collisions were less than 30 years of age (Table 5.5). This effect was most evident among the male drivers, who accounted for 64 percent of the total. There were very few drivers over 60 years of age in this sample of pedestrian crashes despite the over-representation of daytime cases.

Table 5.5
Age and sex of the driver of the vehicle: P and M series combined

Age (years)	Sex		Total number of drivers
	Female	Male	
<20	4	6	10
20-24	7	20	27
25-29	3	17	20
30-39	16	24	40
40-49	8	14	22
50-59	13	9	22
60-69	2	2	4
70-79	3	6	9
80+	0	3	3
Total	56	101	157

Note: one driver of unknown age. Note also these figures include drivers who may have struck the pedestrian after a collision with another vehicle.

5.2.5 Characteristics of the pedestrians

The age and sex distributions of the pedestrians involved in the 154 collisions investigated are listed in Table 5.6. There were equal numbers of male and female pedestrians, contrasting with the sex difference of the drivers of the striking vehicles.

The age distribution reflects the age distributions seen in the sources of mass accident data presented earlier in this report (TARS and hospital separations).

Table 5.6
Pedestrian age and sex M and P series combined

Age range (years)	Sex		Total number of pedestrians
	Female	Male	
0-9	2	11	13
10-19	18	24	42
20-29	7	10	17
30-39	7	10	17
40-49	7	12	19
50-59	5	3	8
60-69	13	3	16
70-79	14	4	18
80-89	8	3	11
Total	81	80	161

The age and sex distributions for those pedestrians who were fatally injured or who were admitted to hospital are listed in Table 5.7. As would be expected, a smaller percentage of the younger pedestrians (less than 40 years of age) are in these two outcome categories than is the case for the older pedestrians (49 percent and 73 percent, respectively).

Table 5.7
Pedestrian age and sex: P and M series
(Those fatally injured or requiring hospital admission)

Age range (years)	Sex		Total
	Female	Male	
0-9	1	7	8
10-19	8	13	21
20-29	3	5	8
30-39	4	5	9
40-49	5	9	14
50-59	3	2	5
60-69	10	2	12
70-79	9	3	12
80-89	7	3	10
Total	50	49	99

The severity of the collisions is shown for males and females in Table 5.8.

Table 5.8
Injury outcome for each injured pedestrian: P and M series
(in terms of fatality or mode of treatment received)

Severity of injuries	Sex		Total number of pedestrians
	Female	Male	
Fatal	10	12	22
Admitted to hospital	40	37	77
Treated at hospital	28	24	52
Private doctor	2	3	5
Unknown		1	1
non-injury	1	3	4
Total	81	80	161

The body regions injured for the pedestrians in the study sample are listed by injury severity in Table 5.9. Minor injuries, defined as Level 1 injuries on the Abbreviated Injury Scale (AIS 1) are not shown. Lower extremity (leg and pelvis) and head injuries accounted for two thirds of all AIS 2+ injuries. This proportion did not change for AIS 3+ injuries but the ratio of head to lower extremity injuries did, with head injuries alone accounting for more than 40 percent of all injuries in this more severe injury category.

Table 5.9
All recorded injuries by body region: P and M series

Body region	AIS 2+		AIS 3+	
Head	59	(30%)	41	(44%)
Lower extremity	57	(29%)	21	(22%)
Upper extremity	29	(15%)	3	(3%)
Thorax	15	(8%)	14	(15%)
Spine	12	(6%)	8	(9%)
Face	10	(5%)	2	(2%)
Abdomen	11	(6%)	5	(5%)
Neck (exc. Spine)	1	(1%)	-	
Total	194	(100%)	94	(100%)

5.3 Pedestrian behaviour

There was a preponderance of collisions where the pedestrian crossed from the drivers' left (i.e. from the kerbside direction). About half of all crashes occurred in this way. A further 29% occurred with the pedestrian crossing from the drivers' right. Table 5.10 gives the number and proportion of pedestrian movements in the two sets of data.

Table 5.10
Movements of pedestrians: P and M series

Movements of Pedestrian(s)	Number and percentage of cases	
Crossing from driver's left	79	(51%)
Crossing from driver's right	44	(29%)
Standing/moving on footpath or verge	10	(6%)
Stationary in traffic lane	5	(3%)
On road, moving with traffic	3	(2%)
Vehicle turning right, crossing from driver's left	7	(5%)
Vehicle turning right, crossing from driver's right	3	(2%)
Standing on centerline	3	(2%)
Total	154	(100%)

The orientation of the pedestrian at impact (Table 5.11) reflects the movement data just described. In 85% of the cases, the pedestrians were struck side-on.

Table 5.11
Orientation of the pedestrian at the time of collision in the P and M series
(percentages shown are of known orientations)

Orientation to vehicle	Number and percentage of pedestrians	
Right side to vehicle	81	(55%)
Left side to vehicle	44	(30%)
Back to vehicle	8	(5%)
Lying on road	5	(3%)
Facing vehicle	9	(6%)
Unknown	14	-
Total	161	

5.4 Characteristics of the vehicles

The type of striking vehicle is cross-tabulated with the decade of manufacture in Table 5.12a and 5.12b. Passenger cars and derivatives accounted for more than two thirds of the vehicles in this sample of pedestrian collisions.

The more recent M series contains more vehicles that are classed as sport utility vehicles (including high ground clearance 4WDs) possibly reflecting the increasing popularity of this class of vehicle.

The preponderance of passenger vehicles in pedestrian crashes emphasises the relevance of vehicle standards relating to passenger safety. However, the age distribution of the vehicles (similar to that of all motor vehicles in Australia, where the median age of a vehicle is about 10 or 11 years) also emphasises the time lag for the benefit of any new design standard to be realised.

Table 5.12a
Type of striking vehicle by decade of manufacture: M series

Type	Decade of manufacture						Total
	1960	1970	1980	1990	2000	not known	
Passenger		13	21	30			64
Four Wheel Drive				1			1
Van			2	1			3
Bus		1	2	1			4
Truck			2	2			4
Motorcycle	1			1			2
Total	1	14	27	36			78

Table 5.12b
Type of striking vehicle by decade of manufacture: P series

Type	Decade of manufacture						Total
	1960	1970	1980	1990	2000	not known	
Passenger		3	17	19	12		52
Utility	1	1	3	1	1		1
Four Wheel Drive				3	3		9
Van				3	1	1	3
Bus			1	2	1		6
Truck			2	2	1	2	4
Total	1	4	23	30	19	3	80

The makes of passenger vehicles and other light vehicles represented in the study sample of pedestrian collisions are shown in Tables 5.13a and 5.13b. The number of cases is small but the proportion by make approximates the proportion of the major manufacturers' passenger cars on the road in Adelaide.

Table 5.13a
Make of passenger and other light vehicles: M series

Make	Number
Ford	16
Holden	14
Toyota	13
Mitsubishi	7
Mazda	4
Suzuki	2
Other	8
Total	64

Table 5.13b
Make of passenger and other light vehicles: P series

Make	Number
Ford	17
Holden	16
Toyota	9
Mitsubishi	4
Nissan	4
Chrysler	3
Datsun	3
Mazda	2
BMW	2
Other	6
Total	66

5.5 Vehicle factors in injury causation

Table 5.14 lists the objects that were associated with the head injuries sustained by the pedestrians. This Table excludes cases in which the striking vehicle was a truck, bus or trailer.

The area adjacent to the windscreen, and the windscreen itself, accounted for one third of the AIS 3+ head injuries. A further third of AIS 3+ injuries were from impacts with the bonnet area.

Table 5.14
Objects causing injuries to the head
(Highest AIS head injury score per pedestrian, excluding cases involving buses, trucks, trailers, etc.): M and P series

Objects	All severities	AIS 3+
A pillar/edge of windscreen	6	4
Windscreen	10	4
Base of windscreen	4	3
Base of windscreen/ wiper arm	2	1
Windscreen & roof	1	1
Bonnet	14	10
Left wing panel	1	1
Bumper	2	
Bonnet leading edge	2	2
Roadway	20	5
Under vehicle	3	3
Total	65	34

All vehicle test procedures currently used to assess pedestrian protection (for example, the Australasian New Car Assessment Program (ANCAP), use headforms to assess the upper frontal surface of the vehicle under assessment. In part of the procedure, the upper surface is divided into regions into which it is thought that head impacts are most likely to occur to children and adults in a collision. Only these regions are assessed in such procedures. The regions are chosen according to the 'Wrap-Around-Distance (WAP)' – the distance from the ground a pedestrian would wrap around the contour of the vehicle in a collision. In our crash investigations we examined where head impacts between pedestrians and vehicles actually took place.

Table 5.15 categorises the head impact locations on the vehicles, where the head impact point could be identified as falling into or outside the two head impact zones (child and adult head impact zones) defined by the pedestrian test procedures such as EuroNCAP and ANCAP. As would be expected, this table indicates that there was some overlap in the distribution of head impact locations for children and adults. A significant number of adults also struck their heads beyond the limit of the adult headform test area, suggesting that structures beyond this line need to be included in considerations of pedestrian head protection. Several of these crashes occurred when the pedestrians walked into the side of the vehicle in the vicinity of the front wheel, and fell onto the vehicle structures that were to the rear of the adult headform impact zone, such as the upper portion of the A-pillar.

Table 5.16 lists the structures identified as being struck by the head of the adult pedestrian, irrespective of the head injury severity, in the PED series. This Table also indicates that the head commonly comes into contact with structures that are usually beyond the 2100 mm WAD line on larger family cars, such as the windscreen, A-pillar and base of windscreen.

Table 5.15
The WAD to head impact location by age of pedestrian in the M and P series irrespective of severity

Contact zone	Age range (years)			Total
	6-10	11-18	19 +	
WAD < 1000 mm	0	0	0	0
1000 mm < WAD < 1500 mm (child headform zone)	3	2	3	8
1500 mm < WAD < 2100 mm (adult headform zone)	2	7	21	30
WAD > 2100 mm	0	0	14	14
Unknown		1	5	6
Total	5	10	43	58

Table 5.16
Head impact locations on passenger cars in collisions with pedestrians aged 13 and older (irrespective of injury severity): P and M series

Head contact zone	Count	
Windscreen & roof	1	(3%)
A pillar	6	(16%)
Windscreen	10	(27%)
Base of windscreen	7	(19%)
Trailing edge of bonnet	4	(11%)
Bonnet	4	(11%)
Mudguard panel	2	(5%)
Leading edge of bonnet	2	(5%)
Bumper	1	(3%)
Total	37	(100%)

Table 5.17 presents the objects thought to have produced the specified injuries to the lower extremities of the pedestrians. The bumper and the leading edge of the bonnet accounted for almost all of the AIS 3+ injuries to this body region. The wide age range of the vehicles in this study meant that many of the passenger cars had a prominent bonnet leading edge.

Table 5.17
Objects causing injuries to the lower extremity (Highest AIS score per pedestrian for the lower extremity, excluding cases involving buses, trucks, trailers, etc.): P and M series

Object	All severities	AIS 3+
Bonnet	2	
Leading edge	17	3
Bull bar	5	2
Bumper and grille area	48	10
Crushed between vehicle and roadside object	1	1
Side panels and structures	7	
Under vehicle	8	
Roadway	19	1
Total	107	17

5.6 Summary

The in-depth data appear to confirm the focus of vehicle assessment procedures on protecting the head and lower extremities in pedestrian crashes: two thirds of AIS 3+ injuries were to these body regions. However thoracic and spinal injuries were common too.

The structures commonly struck by the head in serious head injury cases include the windscreen area and the bonnet. While the roadway was the most common source of injury when all severities were considered, it could only be attributed as the source of severe injury in around 15% of cases.

Test procedures that are being used to assess the pedestrian safety of passenger vehicles do consider the most commonly struck parts of the vehicle, but it is noteworthy that adult pedestrians often struck their heads beyond the upper limit of the test area (wrap-around-distance of 2100 mm) : a third of adults in our samples did so.

New technology being considered to reduce pedestrian crash risk includes sensors that detect pedestrians either on the roadway or moving in a collision course with the vehicle. In around 75% of cases we investigated there was no obstruction between the vehicle and the driver. In the remaining cases, such technology would have had to deal with some sort of obstruction between the vehicle and the driver.

The ages of vehicles involved in pedestrian crashes highlights the fact that new technology that might be implemented in the future for pedestrian protection may take some years to penetrate the South Australian vehicle fleet. Around half of the vehicles in this sample of pedestrian crashes were imports from overseas automotive companies. Of the vehicles sold by Australian companies, a further significant proportion was also imported. And so it is likely that the fleet is accruing some benefits of overseas regulation in the area of pedestrian safety. However, in the absence of an Australian Design Rule on pedestrian protection, any improvements in the safety of the fleet from imported vehicles will be coincidental or subject the design philosophies of individual companies. An Australian Design Rule would enforce some minimum requirements on locally designed and manufactured vehicles as well as the specification of all imported vehicles, including those imported by Australian companies.

Acknowledgments

We are grateful to other CASR staff that contributed to this report:

- The many staff who collected much of the in-depth data on pedestrian injury collated in Section 5,
- Paul Hutchinson who gave some statistical advice during the preparation of Section 4,
- Jamie Mackenzie who assisted with the preparation of tables in Section 5.

We are also grateful to staff from the Epidemiology Section of the SA Department of Health who performed queries on the hospital separation data to our specification.

This Report was funded by the South Australian Motor Accident Commission (MAC) through a Project Grant to the Centre for Automotive Safety Research. The MAC Project Manager was Ross McColl.

The Centre for Automotive Safety Research receives core funding from both MAC and the Department for Transport, Energy and Infrastructure.

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