Centre for
Automotive Safety Research

Trends in traffic casualties in South Australia, 1981-2003

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CASR REPORT SERIES
CASR008
December 2004

THE UNIVERSITY
OF ADELAIDE
AUSTRALIA

Report documentation

REPORT NO.	DATE	PAGES	ISBN	ISSN
CASR008	December 2004	46	1 920947 06 X	1449-2237

TITLE

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AVAILABLE FROM

Centre for Automotive Safety Research
http://casr.adelaide.edu.au/reports

ABSTRACT

There has been a reduction in traffic fatalities in South Australia between 1981 and 2003, but this has not been accompanied by a fall in the total number of traffic casualties, and even the number of fatalities has declined very little since about 1992. This report throws light on these and related observations. The main data source is TARS, the database of crashes reported to the police; in addition, some use is made of statistics of death registration and of casualties hospitalised. Among the findings are the following. (a) Although the number of fatalities has not fallen much since about 1992, this has been a result of a continued decline in fatality rate and an increase in vehicle kilometres. (b) The increase in total casualties over the period 1992-2000 was largely confined to the minor categories of injury. (c) An increase in minor rear-end crashes was part of this, but not all of it. (d) In the metropolitan area of Adelaide, hospital-admitted casualties have been falling faster than fatalities over the period 1981-2003. (The evidence is less clear for country areas.) (e) There are numerous other features of the data that are not fully understood. In some cases, a more elaborate tabulation of subcategory numbers might resolve the issue, but in other cases, it is difficult to imagine doing so with mass accident data.

KEYWORDS

Accident statistics, Injury rate, Data analysis, Australia - South Australia

Summary

There has been a reduction in traffic fatalities in South Australia between 1981 and 2003, but this has not been accompanied by a fall in the total number of traffic casualties, and even the number of fatalities has declined very little since about 1992. This report throws light on these and related observations. The main data source is TARS, the database of crashes reported to the police; in addition, some use is made of statistics of death registration and from the hospital in-patient morbidity database. Time series of several categories of casualty and crash have been plotted for 1981-2003.

Among the findings are the following. (a) Although the number of fatalities has not fallen much since about 1992, this has been a result of a continued decline in fatality rate and an increase in vehicle kilometres. (b) The increase in total casualties over the period 1992-2000 was largely confined to the minor categories of injury. (c) An increase in minor rear-end crashes was part of this, but not all of it. (d) In the metropolitan area of Adelaide, hospital-admitted casualties have been falling faster than fatalities over the period 1981-2003. (The evidence is less clear for country areas.) (e) There are numerous other features of the data that are not fully understood. In some cases, a more elaborate tabulation of subcategory numbers might resolve the issue, but in other cases, it is difficult to imagine doing so with mass accident data.

A degree of anxiety over recent numbers and where the trends are heading is natural. Our reaction to the data is that some of the concern is overstated because it results from attention to numbers rather than rates, to particular subsets of accidents rather than others, or to random short-term fluctuations, and that some of the concern is justified.

ABBREVIATIONS

CTP — compulsory third party

ICD — International Classification of Diseases

ISAAC — Integrated South Australian Activity Collection, the SA in-patient statistics system

PDO — property damage only (i.e., no person is injured)

SA — South Australia

TARS — Traffic Accident Reporting System (based on crashes reported to the police)

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1 Introduction

The starting point for this project was Figure 1. This shows there has been a reduction in traffic fatalities in South Australia between 1981 and 2003, but that this has not been accompanied by a fall in the total number of traffic casualties (which of course largely reflects nonfatal injuries), and that even the number of fatalities has fallen very little since about 1992. Similar points are made in the South Australian annual statistical publication on road crashes (Transport SA, 2003). Perhaps the most dramatic statistic is that from 1989 to 1992, there was a 64 per cent fall in the number of road casualties treated in the neurosurgical department of the Royal Adelaide Hospital (North et al., 1993). The aim of this project was to throw light on these and related observations. In passing, it may be noted that an interesting further point made in Transport SA (2003) is that the State's highest number of fatalities was 382, as long ago as 1974.

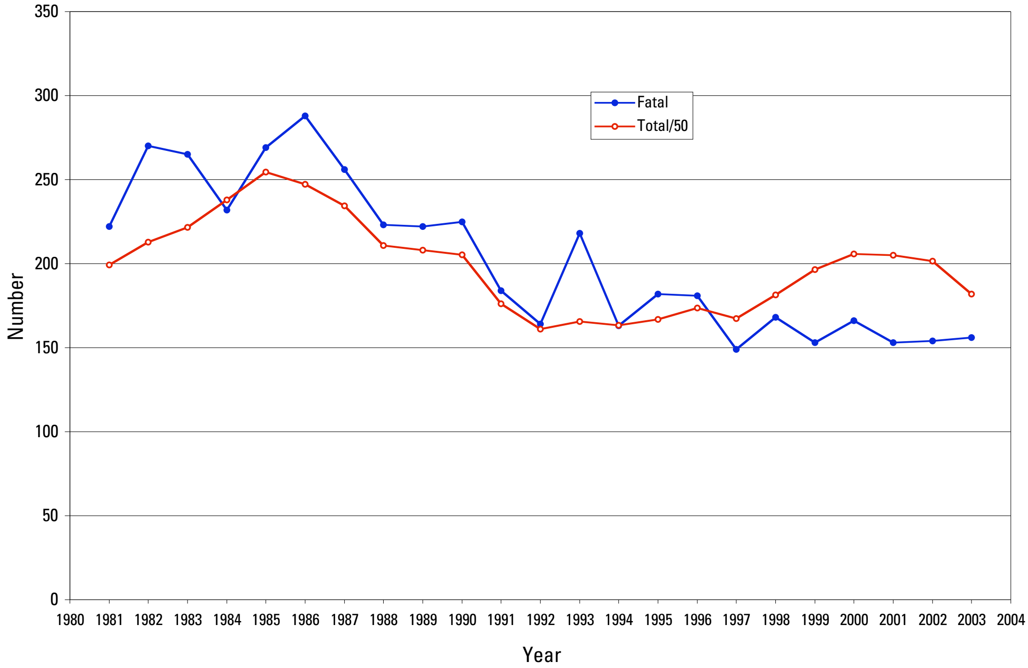

Figure 1. Casualties: fatal, and total divided by 50.

A sceptic might claim that there is unlikely to be any broad-brush intelligible explanation for these numbers. Many agencies are continually intervening in the road traffic system, trying to make it safer and more efficient. The interventions --- whether they be vehicle engineering, traffic engineering, legislation, or policing — often do have some effect on road safety. And different interventions affect different subclasses of accidents. The sceptic would say that it might be possible to understand a change from one year to the next in respect of one type of accident to one category of person in one locality, but that there is no overarching explanation of the total numbers.

Turning now to the trend specifically in fatalities, it is not likely that detailed conclusions will be possible, as fatalities (fortunately) are fairly few in number. If a purely random event is happening at a rate of 160 per year, a year-to-year variation of 10 or 20 or perhaps 30 is not unusual. (For further discussion of random variation, see below.) Disaggregation of fatalities into such categories as late night, child pedestrian, young driver, motorcyclist, elderly, and so on, will further reduce the number, and chance variation will be a larger proportion of this.

Despite the reservations expressed in the previous paragraphs, many interesting features of the accident statistics will be found and reported below. This report is largely a descriptive one: a lot of information will be presented in the form of graphs showing how road casualty numbers in South Australia have evolved over the period 1981-2003. To prove why the changes occurred and to predict whether the reasons will continue to operate in future years is beyond the scope of this project. The report will be structured as follows.

- There will be some discussion of three types of background information.

    Earlier research on road casualties in Australia

    The dataset and the presentation of the graphs in this report

    Random variation in accident and casualty numbers

- Most of the report will use TARS data. (TARS, the Traffic Accident Reporting System, is a database maintained by Transport SA that is based on crashes reported to the police.) These data will be discussed under the following headings.

    Disaggregation by severity

    Exclusion of rear-end crashes

    Comparison of metropolitan and country trends

    Trends in severity

    Disaggregation according to characteristics of accident

    Comment on the trends in casualty numbers in different categories

- A comparison will be made of TARS with other datasets, notably, fatalities as recorded by the death certification and registration process, and the numbers of hospital-admitted casualties recorded by the hospital in-patient statistics system.
- Consideration will be given to some macroscopic independent variables, such as total vehicle kilometres travelled per year, that convert the accident numbers into rates, and to economic variables that might affect road casualty numbers above and beyond the effect of vehicle kilometres travelled per year.
- Conclusions.

2 Background

2.1 Earlier research

Two reports from 1993 by Anderson and colleagues deal with trends in road fatalities (not total casualties) over the period 1970-1990, in Australia and elsewhere. Anderson et al. (1993a) disaggregate the data according to state (of Australia), casualty characteristics (road user category, sex, and age), and time (time of week and month of year). Several types of rate are calculated: per person, per vehicle, and per kilometre of travel. Australia-wide, the fatality rate per km decreased at an average rate of 4.9 per cent per annum between 1970 and 1990. There is much detail in the report: for example, we find from Table 3.3.2 there that the fatality rate per person of drivers aged 17-19 in South Australia decreased at an average rate of 4.2 per cent per annum. Anderson et al. (1993b) compared 20 industrialised countries, and concluded that Australia's decrease in fatality rates was slightly better than for most other countries. Li and Routley (1998) calculated fatality and injury rates (per person) for Victoria for the years 1984-1996. One of their findings was that the decrease was sharpest from 1989 to 1991, which is at about the same period as in South Australia (see Figure 1). Data from the hospital system of Western Australia for the period 1968-1987 were analysed by Harris et al. (1992). They found some evidence of a steeper decrease in severe injuries than in minor ones.

O'Connor (2000) reported some trends in road casualties in South Australia over the period 1986-1998: many of the graphs are similar to those in the present report, but there are several that are rather unusual. In these, the numbers according to the hospital in-patient statistics system (see Figure 39 below) were disaggregated according to severity. This was done by assigning a code on the Abbreviated Injury Scale to each of the ICD (International Classification of Diseases) categories (which is what the hospital statistics system records). O'Connor reports less of a decline for the more severely injured casualties than for the less severely injured: 29 per cent and 44 per cent, over the period 1986 to 1998. In O'Connor (2002), there are some experts' reactions to trends in road casualties in South Australia over the period 1986-1998. What O'Connor did in this study was to prepare nine graphs of the trends, circulate them to several people who were in a position to be able to comment intelligently, and collate and discuss their responses. There are interesting comments in the report, both concerning the trends themselves and concerning errors and distortions in the datasets — but, as in most literature of this type (including the present report), very little that is conclusive.

2.2 The processing and presentation of the data

As mentioned above, the chief source of data is the Traffic Accident Reporting System (TARS), a database maintained by Transport SA that is based on crashes reported to the police. These data for the years 1981-2003 have been made available to the Centre for Automotive Safety Research, and can be tabulated and cross-tabulated in numerous ways.

- For part or all of 1982, 1993, and 2003, property damage only (PDO) crashes are absent from the dataset. This does not affect most of the time series that have been plotted in the present report, which refer to casualties, but it does affect some of them, and thus gaps appear in the series.
- It should also be noted that the reporting limit for property damage only crashes has changed over time: $300 from 1 January 1980, $600 from 1 January 1988, and $1000 from 1 January 1998. (The number of property damage only crashes that were reported was 12 per cent fewer in 1988 than in 1987, but such a change did not occur in 1998. See Figure 2 below.) A new form for data capture was introduced on 1 October 1981. According to O'Connor (2002), it was 1992 when changeover from paper- to computer-based data collection took place.
- Casualties are classified as fatal, admitted to hospital, treated at hospital, or treated by doctor, and there are property damage only crashes also.

For more details about the data, see the introductory pages of the annual road crash statistics publication (Transport SA, 2003). For a review of procedures of collecting and processing road accident statistics in many different jurisdictions, see Hutchinson (1987).

It is worth pointing out here — particularly since quite a long time period, 23 years, is being discussed — that the relative numbers of crashes of the several severities are influenced both by matters of substantive road safety importance (e.g., speed, crashworthiness) and by matters that are not (e.g., readiness to report minor injury, administrative procedures). Among the latter are likely to be the following (see Hutchinson, 1987, and O'Connor, 2002).

- Recording of PDO crashes is particularly susceptible to the wishes of the people involved and administrative decisions by the police and other agencies.
- Whether someone is recorded as having received any treatment or not will depend upon them classifying their injury as worthy of report or not (which is likely to depend on their perception of the risk of a disabling condition developing some days after the accident), and on the manner with which the police enquire into the condition of the casualty.
- Whether someone is taken to hospital will depend (in part) upon the advice given to them by the ambulance personnel. While this will largely be tailored to their condition, it will also by affected by the policies adopted towards such injuries as a bang on the head or a sore back.
- Whether someone is admitted to hospital or treated as an outpatient will depend on policies towards cases that might possibly be serious but probably are not (closed head and body injuries), the methods available for investigation of such cases in the hospital emergency department, the methods available for immediate treatment of serious but not life-threatening injuries such as limb fractures, and policies towards casualties who might be seriously inconvenienced if they are not admitted (e.g., if they are frail, or are hundreds of kilometres from home).
- More positively, there is no reason to think that the definition of a “death” has changed over the period concerned. (The major issue is the period of time within which the death must occur in order for it to be included in the police statistics. This has remained as within 30 days of the accident.)

Two notes about the presentation of the graphs below may be made at this point.

- In many cases, the numbers of casualties of the different types are very different from one another. Consequently, in order to use a common scale, it has been necessary to divide one or more of the sets of numbers by some constant (e.g., 10 or 100).
- The dots representing data for successive years have been connected by lines. The psychological impression this gives may be misleading (or may not be). For example, in Figure 1, the total number of casualties appears to increase from 1997 to 2000 and then level off in 2001 and 2002. The impression of such a pattern is less if the dots are not connected.

2.3 Random variation in accident and casualty numbers

It has been noted above that if a purely random event is happening at a rate of 160 per year, a year-to-year variation of 10 or 20 or perhaps 30 is not unusual. This is derived as follows. The description "purely random" implies that the number of events follows the Poisson distribution. Thus the standard deviation is the square root of the mean — for example, if the expected number of events is 144, the standard deviation is 12. It is not unusual for an observation to be 1 or 2 standard deviations from its expected value. Furthermore, if we are referring to the difference between the numbers from one year to the next, the standard deviation of this will be $\sqrt{2}$ times bigger again. The vague description "10 or 20 or perhaps 30" came from $\sqrt{(160)}$ multiplied by the vague "1 or 2" multiplied again by $\sqrt{2}$.

However, there is evidence that the year-to-year variation in the number of road accidents is rather larger than is implied by the Poisson distribution (Hutchinson and Mayne, 1977). That is, their occurrence is not purely random. Hutchinson and Mayne noted that weather varies from year to year, changes are made in road safety legislation, and the road network and the vehicles on it change. They based their conclusions on British data, but the next two paragraphs will demonstrate the same to be true for the South Australian numbers (Figure 1).

Firstly, consider variability in the numbers according to the police. For the period 1992-2003, when there was no strong trend, the mean and standard deviation of the annual number of fatalities were 167 and 19, and the mean and standard deviation of the annual number of casualties were 9042 and 860. The Poisson distribution is a poor method of predicting the standard deviations, as it would suggest $\sqrt{(167)} = 13$ and $\sqrt{(9042)} = 95$, not 19 and 860. As a percentage of 9042, 860 is 9.5. However, it is possible, even likely, that some of the excess variability is not random, but could (in principle) be traced to specific events or interventions.

Secondly, consider variability in the ratio of the numbers according to the police and according to hospital statistics. Later in this report, it will be shown that the number of hospitalised casualties according to the police is about 56 per cent of the number according to hospital statistics (Figure 41). That the numbers differ will not be a surprise to anyone familiar with the difficulties faced by systems for processing routine statistics. But what is of present relevance is that the ratio varied between 49 and 63 per cent (during the period from 1988 to 2002). The great majority of matters of real road safety importance would be expected to affect the police and hospital statistics similarly, and not to affect the ratio. Consequently, the variation in the ratio is likely to chiefly reflect reporting and administrative issues. The standard deviation associated with the mean of 56 per cent was 4.6 per cent. Expressed as a percentage of 56 per cent, 4.6 per cent is 8.2. Some of this variability might be attributable to the hospital statistics, but it seems likely most error is in police statistics (since in many cases it is difficult for the police to know if a casualty was or was not admitted to hospital).

Thus it seems that, as a round number, 10 per cent seems to fairly describe the variation in accident or casualty numbers. Further, the excess variability implies that many of the familiar methods of statistical testing will be inappropriate, except when the accidents or casualties are few. (The methods that are inappropriate are those based upon the Poisson distribution, including the usual chi-squared tests.)

Some trends and changes to be seen in the graphs are obviously so large that they must be genuine, and some are obviously so small that they could easily be the result of chance. The remarks in this Section are intended to help the reader judge whether a trend or change is likely to be genuine or chance. Rather little use has been made in this report of statistical testing to aid in that judgment. The reason is that statistical tests should really only be performed of hypotheses that existed before the data were examined. An example of the problem will be seen in Section 6.4: whether or not a trend is statistically significant depends upon exactly which years are included.

3 Disaggregation of crashes by injury severity

In this Section, a comparison will be made of the trends in the different severities of crash. In order to include the most minor category, property damage only crashes, the numbers plotted will refer to crashes, not casualties.

Figure 2 shows that the numbers of the less serious categories of crashes seem to have been increasing since the early or mid 1990's, but the numbers of the more serious categories have been stable. For greater clarity, Figures 3 and 4 show the same data, but restricted to a limited time period (1991-2003) and to the less serious injuries (Figure 3) or the more serious (Figure 4).

When a steeper fall in fatalities than in serious injuries is found, it is sometimes said that what were previously fatalities are now survivors with severe injury and incapacity. For example, O'Connor (2000) gives some attention to this possibility. We consider it implausible that this is numerically important. It may happen in individual cases that advances in medical treatment result in someone being saved who would previously have died, and that person may have a severe disability. But (a) advances in treatment are only one of many reasons for the decreasing number of road fatalities, (b) the outcome for only a small proportion of critically-injured people is severe permanent disablement, (c) the great majority of advances in treatment result both in people being saved who would previously have died and in improved outcomes for those who would previously survived but had a disability, and (d) the great majority of reasons for a reduction in severity of injury would be expected to apply across the full range of severities.

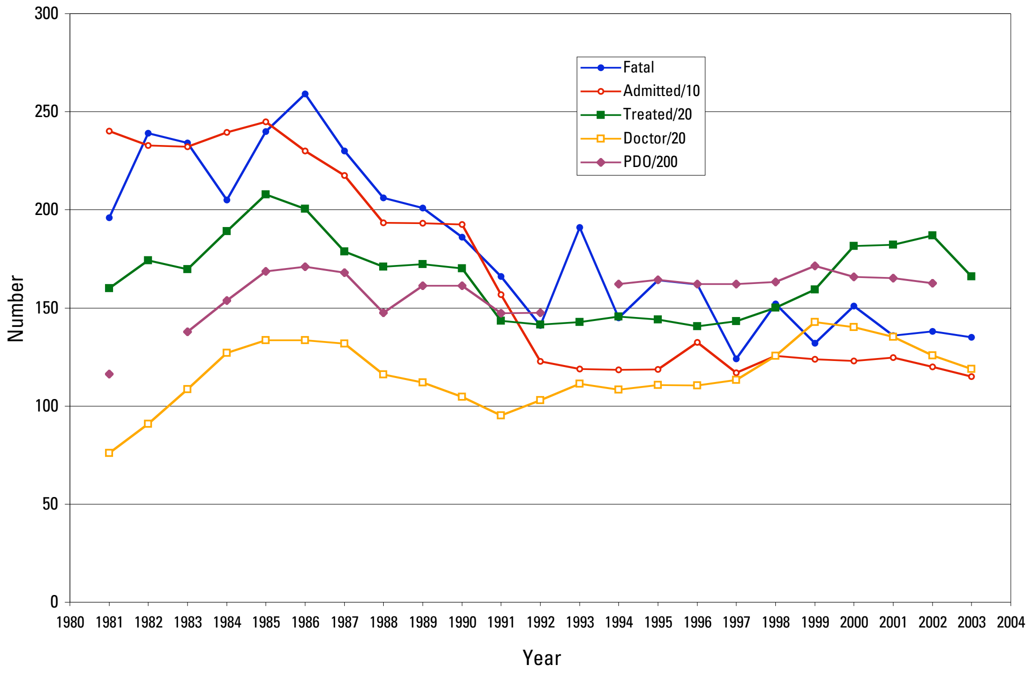

Figure 2. Numbers of crashes, according to severity. (The numbers admitted to hospital have been divided by 10, treated at hospital have been divided by 20, treated by doctor have been divided by 20, and those having property-damage only have been divided by 200.)

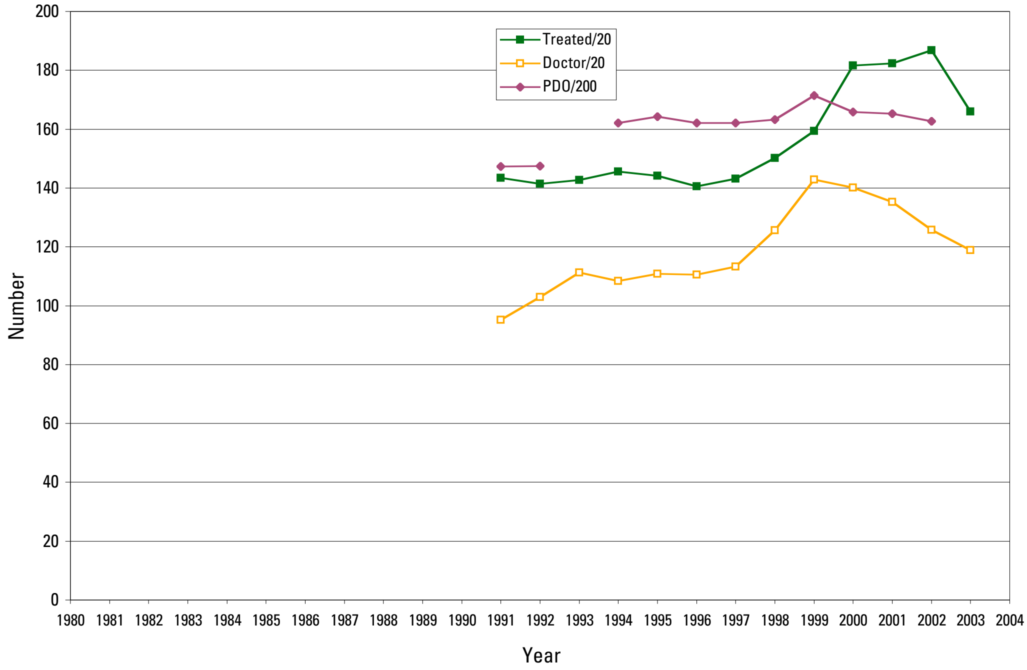

Figure 3. Numbers of crashes: as Figure 2, but limited to the less serious categories and the years 1991-2003. (Treated at hospital have been divided by 20, treated by doctor have been divided by 20, and property-damage only have been divided by 200.)

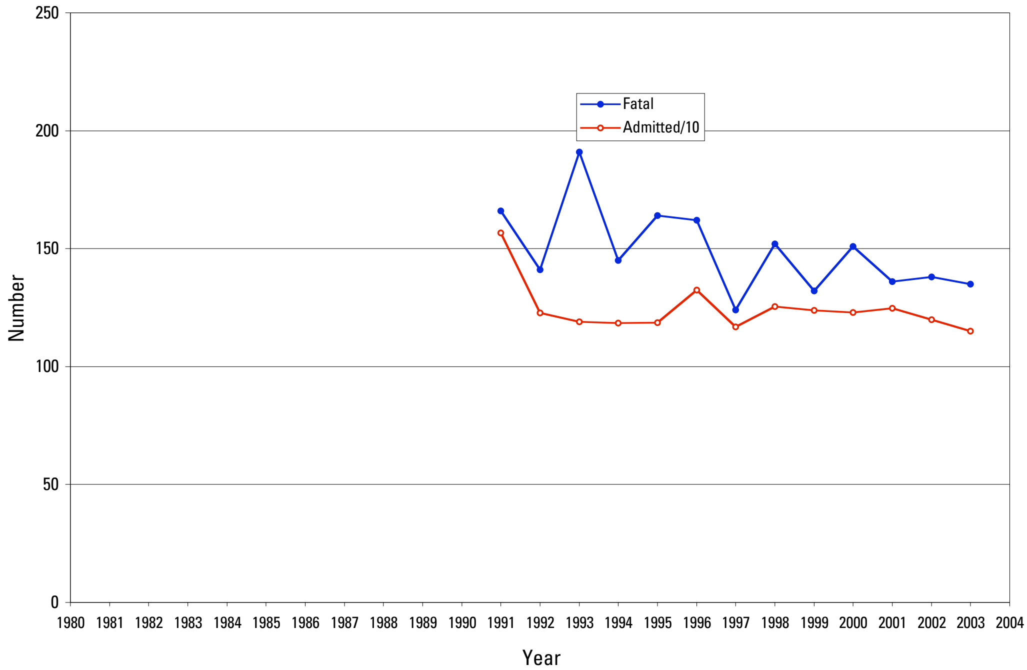

Figure 4. Numbers of crashes: as Figure 2, but limited to the more serious categories and the years 1991-2003. (Admitted to hospital have been divided by 10.)

4 Exclusion of rear-end crashes

Over the period 1981 to 2003, there has been a substantial rise in injuries in rear-end crashes (see Figure 5). In interpreting Figure 5, note that the numbers in the categories of lesser severity have been divided by 10 or 100. It may be seen that the rise is largely confined to the treated-by-doctor category, though there has been a rise over the shorter time period 1991-2003 in the treated-at-hospital category. Although it is impossible to verify such speculation, it may be more common now than it was in 1981 for people to have heard of the minority of aches and pains that turn out to be serious and disabling and, wishing "to be on the safe side", to report soreness or stiffness (e.g., of the neck or back) to their doctor.

Might the changes in numbers of rear-end crashes explain the puzzles in Figure 1? Figure 6 shows the time series of fatalities and casualties with rear-end crashes having been excluded. It is not entirely clear what conclusion is appropriate, but the Figure certainly is consistent with the ideas that total casualties have not been declining as fast as fatalities and that the year-on-year changes for both have been worse since about 1992 during the preceding ten years. That is, the exclusion of rear-end crashes has not answered the questions generated by Figure 1.

Another aspect of this is that in the case of rear-end crashes, there has in recent years been a rise in the ratio of casualty crashes to total crashes, see Figure 7. However, that Figure also shows that the rise was confined to a fairly short time period (1995-2000), and Figures 7 and 8 together show that it also occurred to a greater or lesser extent in some other types of accident (right turn, right angle, rollover, left road out of control, hit fixed object, and hit object on road). (The types of crashes in Figure 7 usually involve at least two vehicles that have drivers in them, and those in Figure 8 usually involve one moving vehicle only.) Of course, because the numbers of PDO crashes are so important in determining the ratios in Figures 7 and 8, the reservations about routine accident data that were noted earlier (Section 2.2) apply with particular force here.

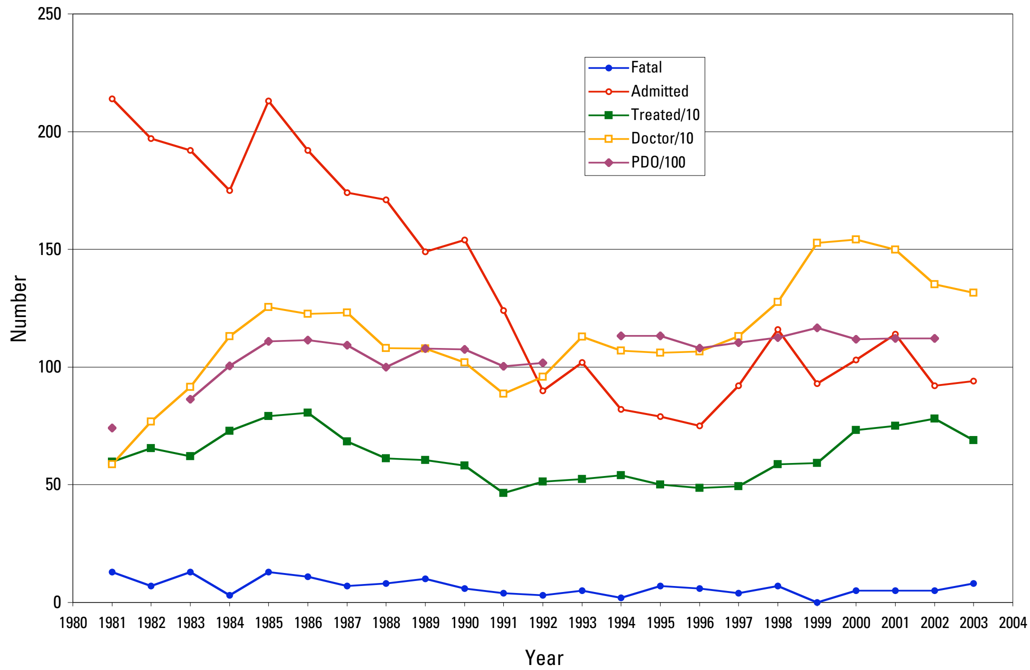

Figure 5. Numbers of rear-end crashes. (Treated at hospital have been divided by 10, treated by doctor have been divided by 10, and property-damage only have been divided by 100.)

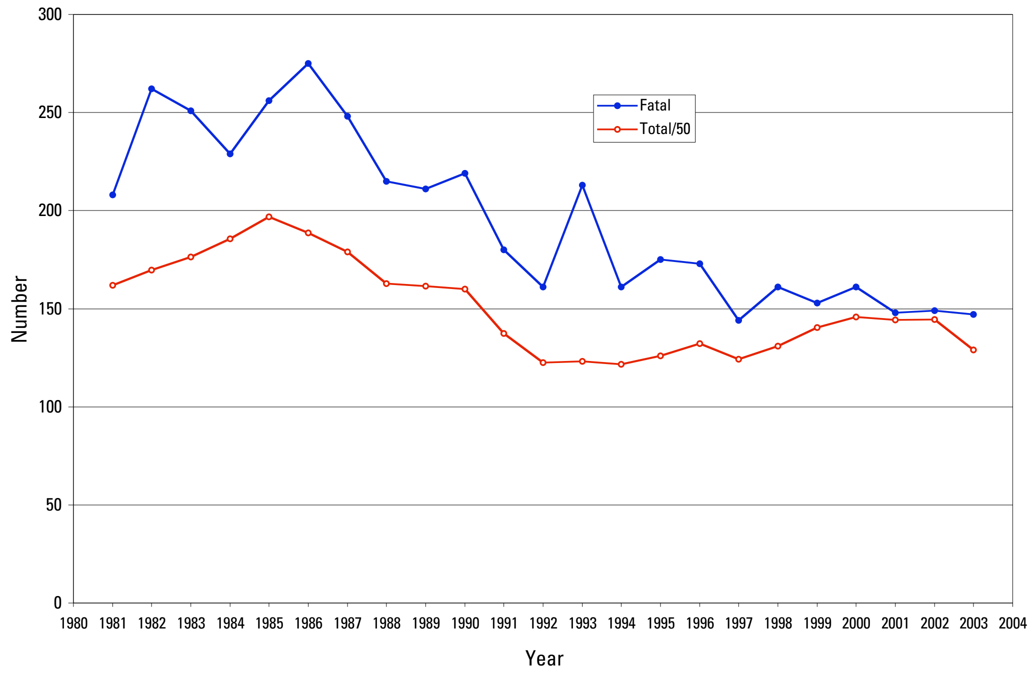

Figure 6. Numbers of casualties, with rear-end crashes having been excluded. (Total casualties have been divided by 50.)

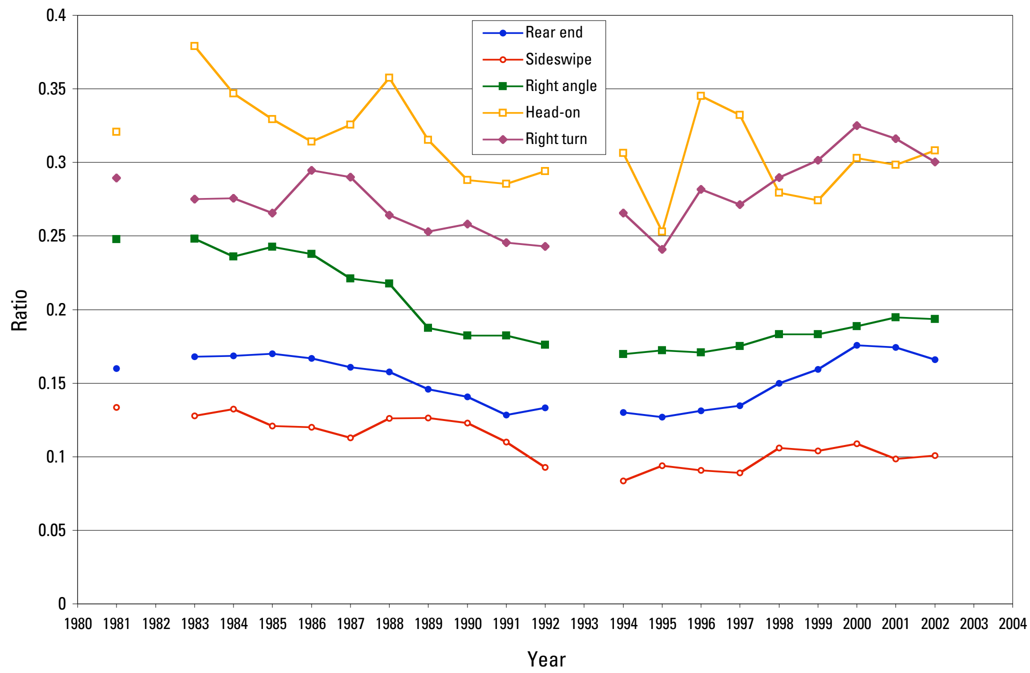

Figure 7. Ratio of casualty crashes to all crashes: comparison of the rear end, sideswipe, right angle, head-on, and right turn categories. Data for 1982, 1993, and 2003 are omitted (see Section 2.2).

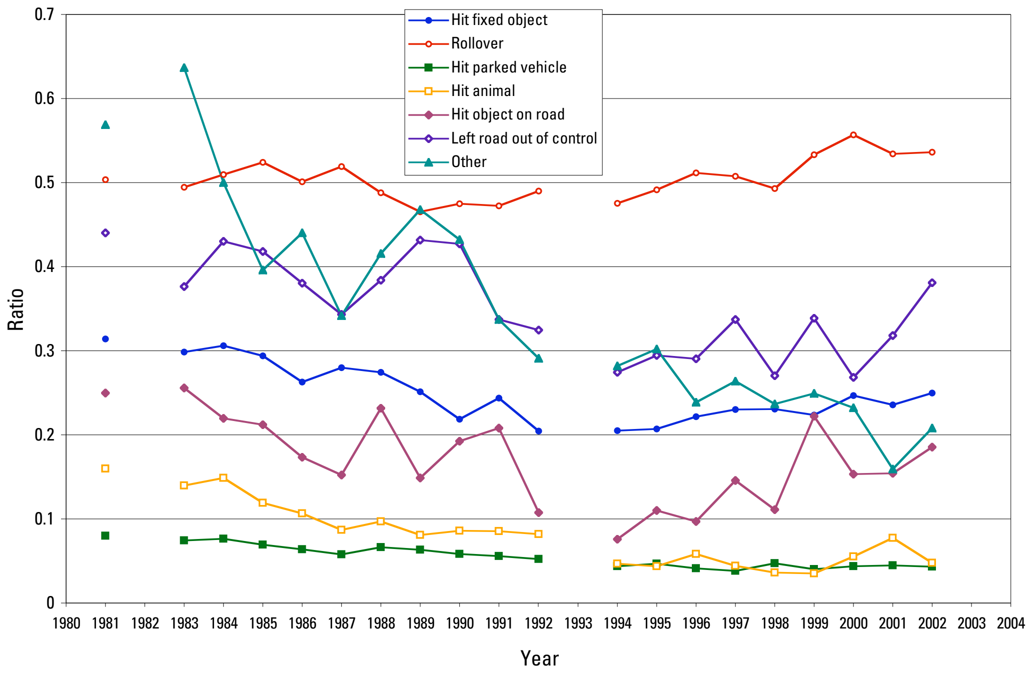

Figure 8. Ratio of casualty crashes to all crashes: comparison of the hit fixed object, rollover, hit parked vehicle, hit animal, hit object on road, left road out of control, and other categories. Data for 1982, 1993, and 2003 are omitted (see Section 2.2).

Continuing to consider crashes other than rear-end, Figures 9 and 10 examine the question of whether anything very different has happened in metropolitan Adelaide from what has happened in country areas. (By country areas, we mean all of South Australia other than metropolitan Adelaide; this includes six urban areas having populations of over 10000.) In those Figures, casualties have been categorised as fatal, admitted to hospital, or treated (i.e., the treated at hospital and treated by doctor categories together).

- As with earlier graphs, these graphs are inconclusive about what has been happening with fatalities and casualties admitted to hospital: it could be that the decline since about 1994 has been at about the same rate as before, but it could be that the decline has been virtually zero since then.
- Figures 9 and 10 do suggest that the rise in casualties over the period 1994-2002 is largely restricted to those slightly injured (i.e., not sufficiently to be admitted to hospital) in metropolitan Adelaide. An obvious possibility is that slightly-injured casualties have become more conscientious in reporting injury, perhaps because of a perception that some forms of injury may become apparent days or weeks after the accident, and in case this happens, the accident itself ought to be reported to the police close to its time of occurrence.

Figure 11 contrasts what has been happening in Adelaide with what has been happening outside. Again, rear-end crashes have been excluded. It makes the contrast by plotting the ratio of casualties in Adelaide to those in country areas, and doing this separately for fatalities, casualties admitted to hospital, and casualties treated by hospital or doctor. For fatalities, the ratio of Adelaide to country has been declining. This is so also for casualties admitted to hospital, albeit perhaps with a less steep slope, but is not so for casualties treated by hospital or doctor.

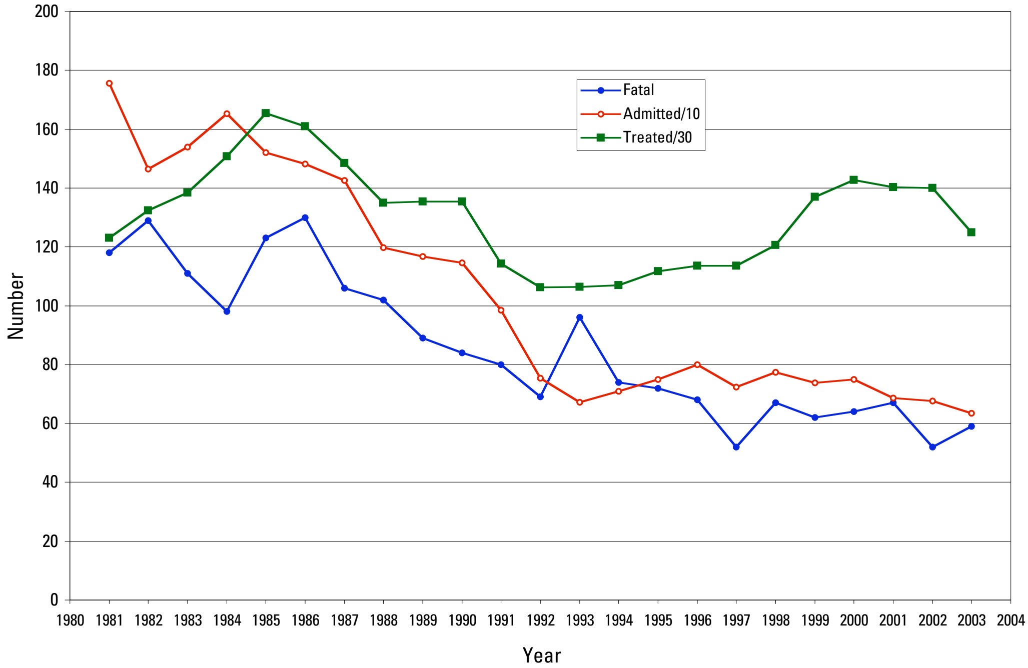

Figure 9. Casualties in Adelaide, with rear-end crashes having been excluded: comparison of fatal, admitted to hospital (divided by 10), and treated by hospital or doctor (divided by 30).

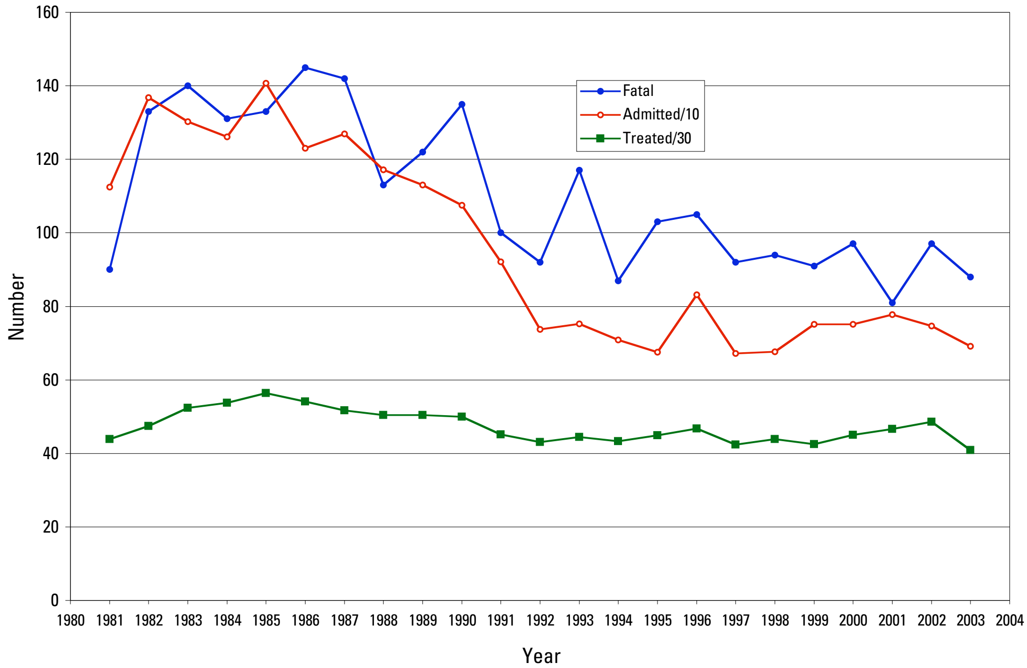

Figure 10. Casualties in country areas of South Australia (i.e., outside of metropolitan Adelaide), with rear-end crashes having been excluded: comparison of fatal, admitted to hospital (divided by 10), and treated by hospital or doctor (divided by 30).

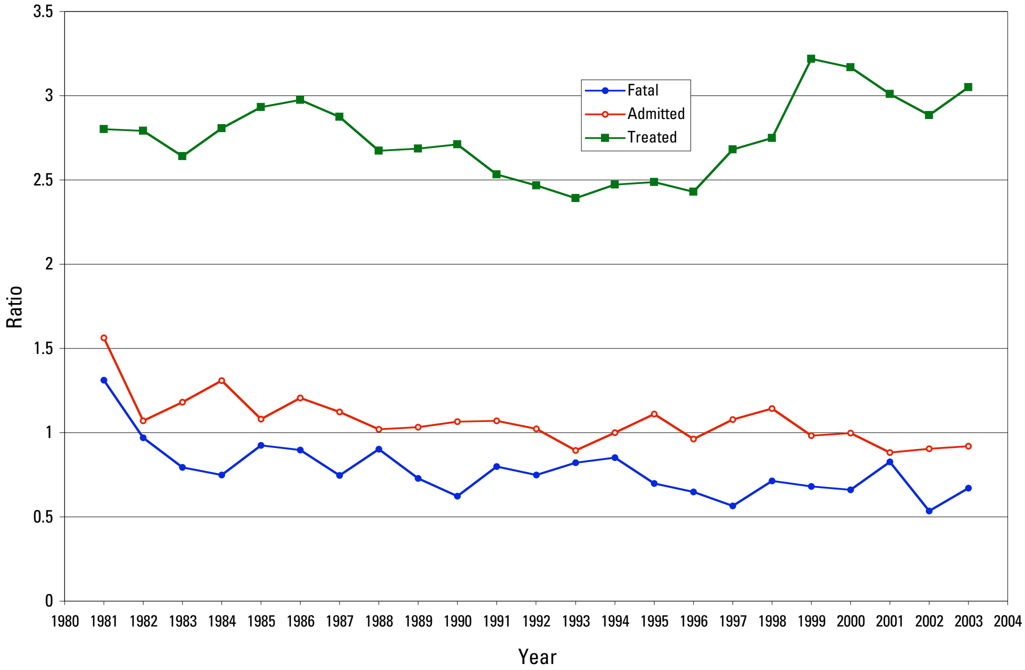

Figure 11. Ratio of casualties in metropolitan Adelaide to those in country areas of South Australia, with rear-end crashes having been excluded: comparison of fatal, admitted to hospital, and treated by hospital or doctor.

5 Trends in injury severity

It seems reasonable to regard the four categories of injury --- fatal, admitted to hospital, treated at hospital, treated by doctor --- as being four levels of severity. In order to summarise severity, there are several different ratios (more severe divided by less severe) that could be calculated. It might be hoped that the same story emerges, whichever ratio is chosen. For example, a reduction in speed at impact or an improvement in vehicle crashworthiness would be expected to lower the ratio of fatal to serious injuries, the ratio of serious to slight injuries, and the other measures of severity. However, that is not the case. It is apparent in Figures 9 and 10 that the hospital-admitted number has been falling at a faster rate than the fatalities. Thus the ratio of fatalities to hospital-admitted has been rising at the same time as the ratio of the more severe categories to the relatively slight has been falling, see Figures 12 (Adelaide) and 13 (country SA). As in Figures 9-11, rear-end crashes have been excluded. The same data is plotted in Figures 14 and 15 in a way that permits an easier comparison of Adelaide and country SA.

The data are consistent with an overall genuine reduction in severity having occurred (which might in turn be the result of lower speeds at impact, improved vehicle crashworthiness, and so on), but this being partly masked by changes in hospital treatment at the emergency department that lead to a lower proportion of people with a given injury being admitted. These are speculations, however.

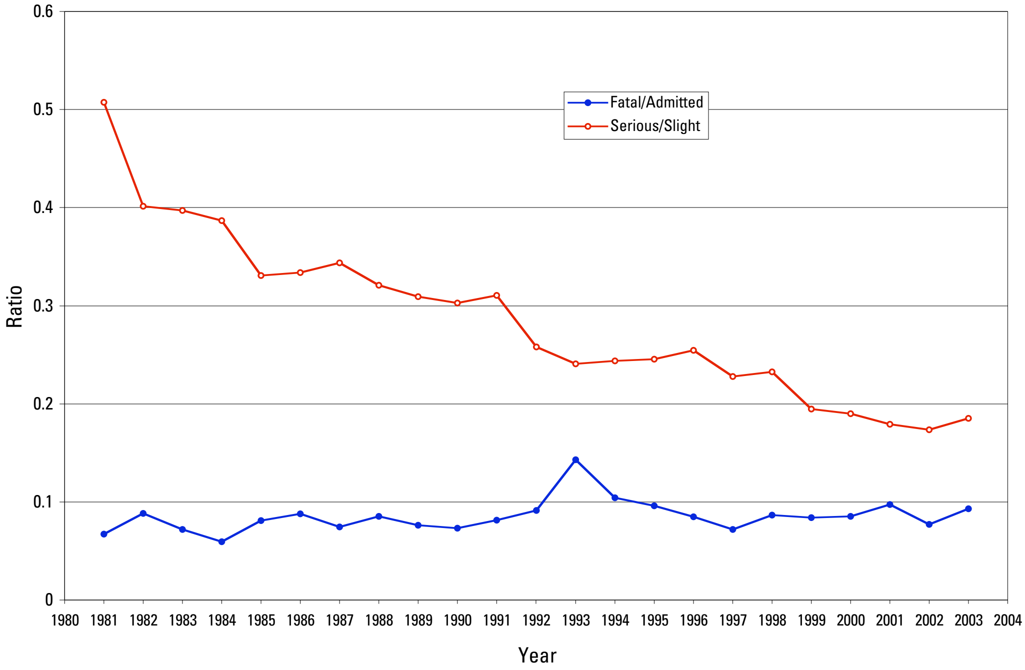

Figure 12. Two measures of severity, rear-end crashes having been excluded, in Adelaide: ratio of fatalities to hospital-admitted casualties, and ratio of the more serious (i.e., fatal plus hospital-admitted) to the relatively slight casualties.

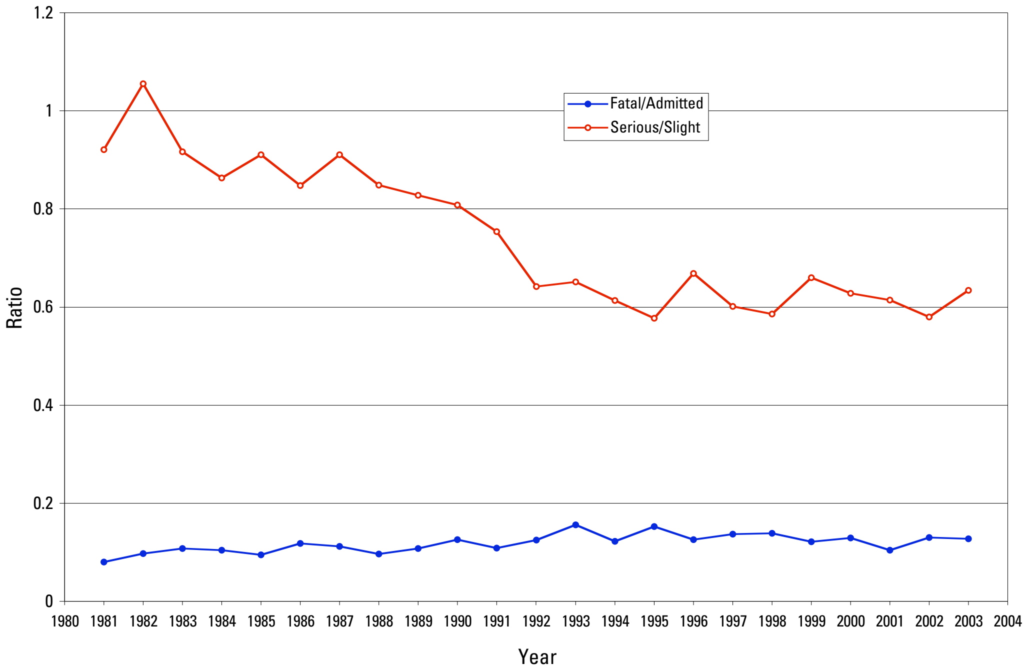

Figure 13. Two measures of severity, rear-end crashes having been excluded, in country areas of South Australia: ratio of fatalities to hospital-admitted casualties, and ratio of the more serious (i.e., fatal plus hospital-admitted) to the relatively slight casualties.

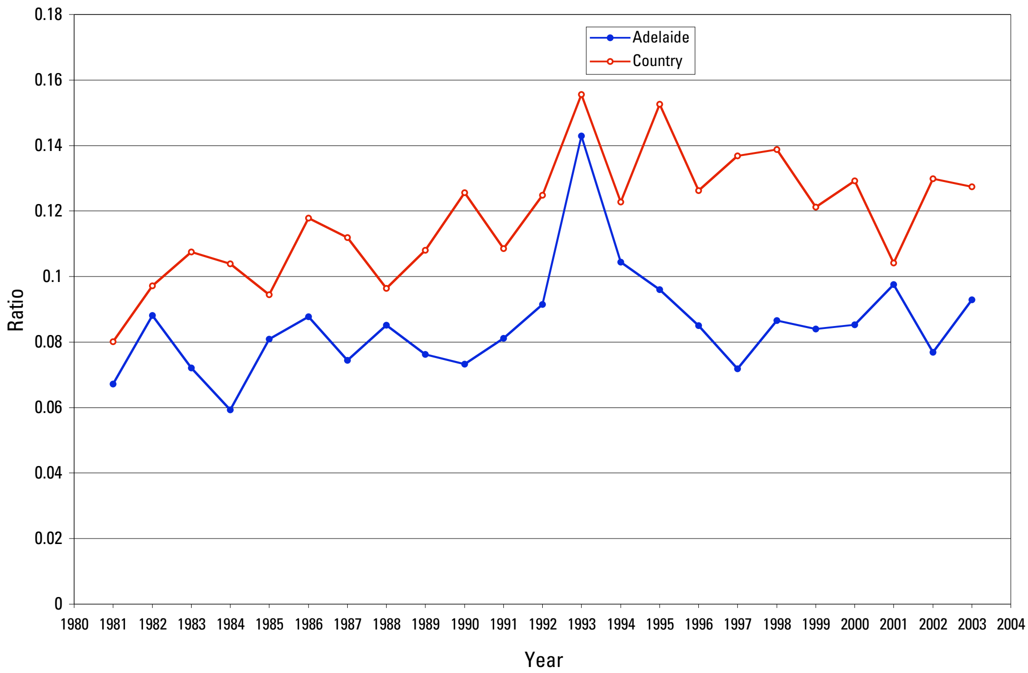

Figure 14. Ratio of fatalities to hospital-admitted casualties, rear-end crashes having been excluded: comparison of Adelaide and country areas of South Australia.

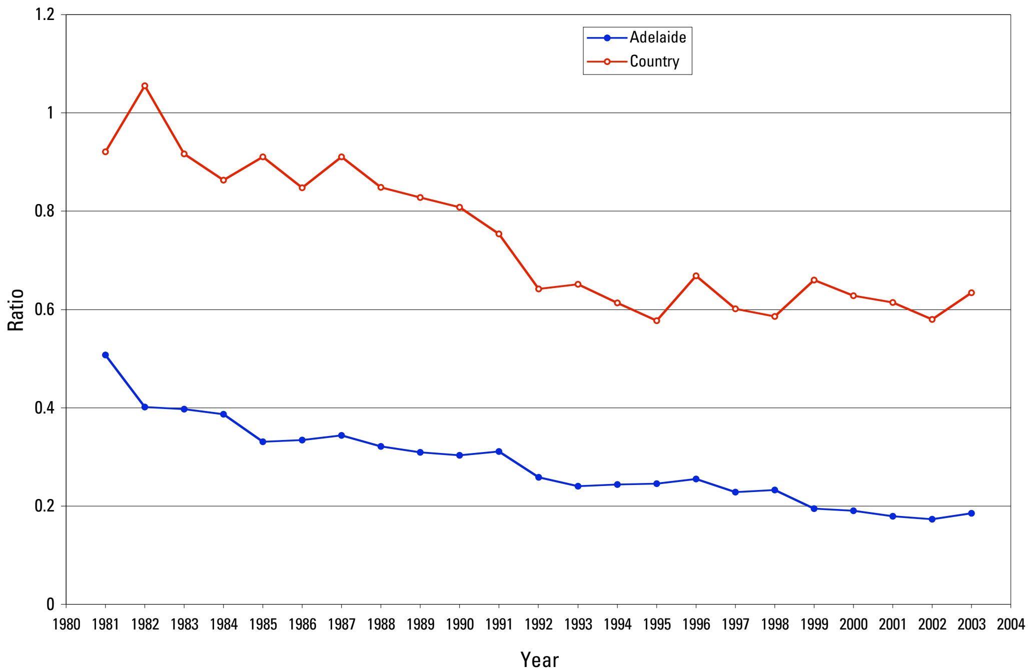

Figure 15. Ratio of the more serious (i.e., fatal plus hospital-admitted) to the relatively slight (i.e., treated by hospital or doctor) casualties, rear-end crashes having been excluded: comparison of Adelaide and country areas of South Australia.

6 Disaggregation according to characteristics of accident

Many disaggregations are possible. Those selected for presentation in this Section are as listed below. There is some discussion in Section 6.9.

- Category of road user
- Hour, with particular attention to night-time accidents
- Child pedestrians
- Teenaged drivers
- Motorcyclists
- Truck drivers
- Persons aged 65-84
- Car occupants, according to speed limit

6.1 Category of road user

Some differences between the several categories of casualty (driver, passenger, rider, pedestrian) are evident in Figure 16. That Figure is supplemented by one in which the numbers are expressed as a percentage of what they were in 1981, Figure 17. There is much similarity between the different categories: from 1981 to 2003, there has been a fall, and the fall was steepest during a few years either side of 1990. However, since about 1994, driver casualties have risen, in contrast to the other categories. The approximately static level of the more serious casualties seen in Figures 9 and 10 seems, therefore, to result from a small rise in driver casualties and small falls in the other categories.

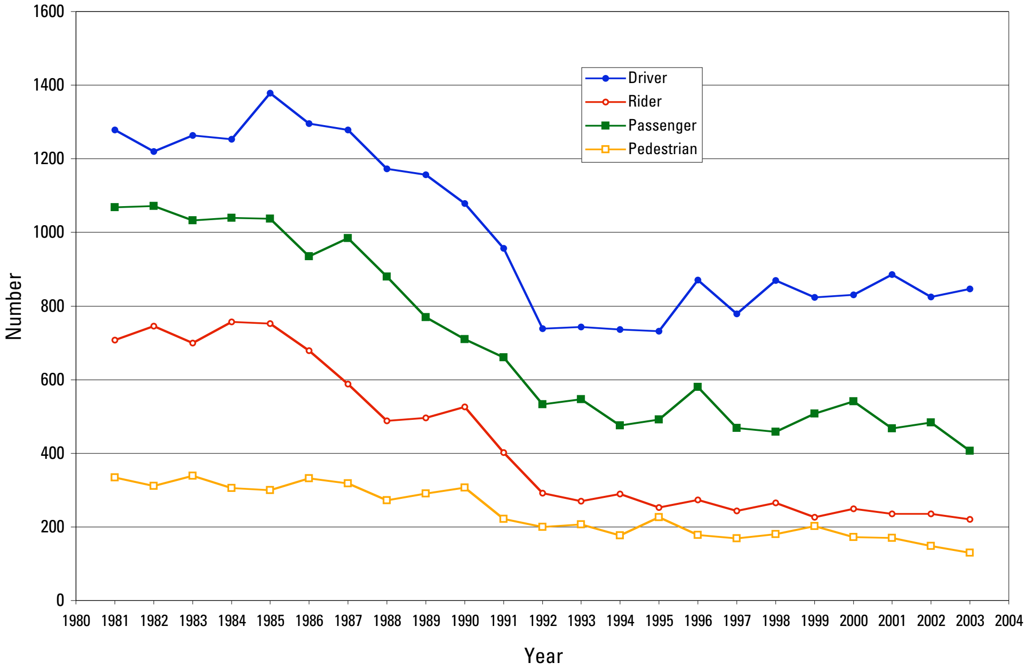

Figure 16. Casualties (fatal and hospital-admitted only): comparison of four categories of road user.

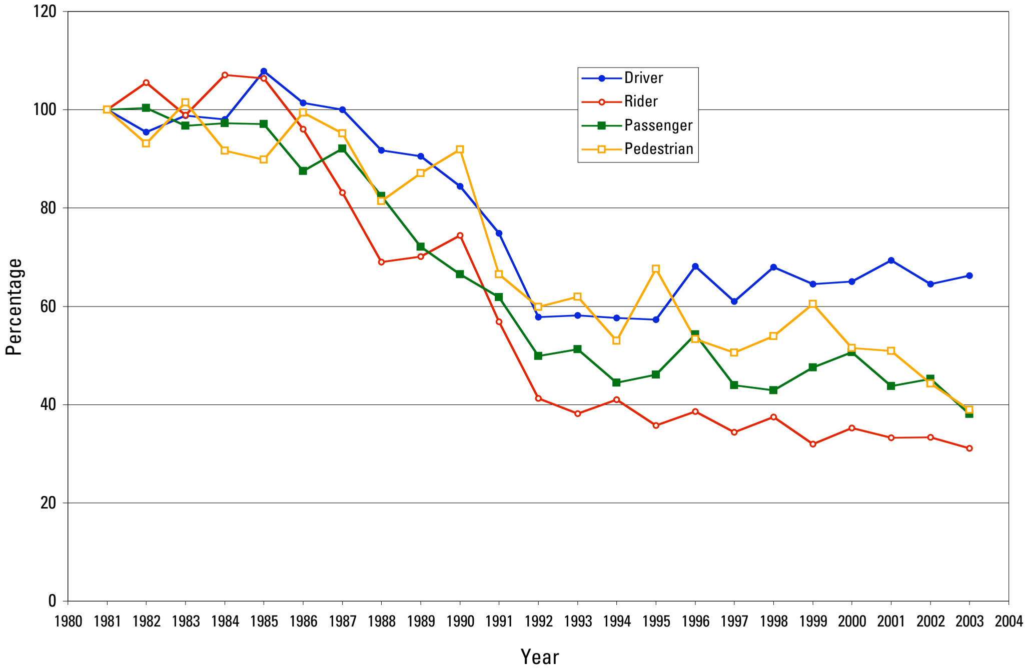

Figure 17. As Figure 16 (i.e., fatal and hospital-admitted casualties), but indexed to a base of 1981 = 100.

6.2 Hour, with particular attention to night-time accidents

Late evening and early morning hours are special for a number of reasons — the relatively high proportions of road users who have used alcohol or other drugs, who are sleepy, who are speeding on the largely empty roads, and so on. Figure 18 shows how the number of such casualties in those hours has evolved over the years, separately for three one-hour periods. Doctor-treated and hospital-treated casualties have been omitted, because Figure 5 shows the numbers of these are behaving quite differently from those of the more severe categories. There seems to have been a fall between about 1985 and 1994, and no change since. This graph is quite persuasive, in the sense that whatever the random element in these numbers, it is sufficiently small that the same pattern repeats in the three sub-samples that have been plotted. In case it be thought that the closing hours of licensed premises have been getting progressively later, and that this may have affected the hour-by-hour casualty numbers, Figure 19 shows the numbers of casualties in the hours beginning 01:00, 02:00, and 03:00, and Figure 20 shows the numbers in the hours 10 pm to 4 am totalled.

However, Figure 21 demonstrates that the pattern in Figures 18-20 is not specific to night-time accidents. But, though the general patterns of the time series are similar, the reduction in casualties was appreciably greater between the hours of 10 pm to 4 am. From the period 1981-1986 to the period 1992-2003, the annual average was reduced by 57 per cent. In contrast, between the hours of 7 am to 10 am, the reduction from one period to the other was 42 per cent. The question of how the reduction varies over the day is taken further in Figure 22. This shows the average number of casualties in the period 1992-2003 expressed as a percentage of that in the period 1981-1986: this was greatest (i.e., the reduction was least) in the hours beginning 5 am, 6 am, and 9 am, and was least (i.e., the reduction was greatest) a couple of hours either side of midnight.

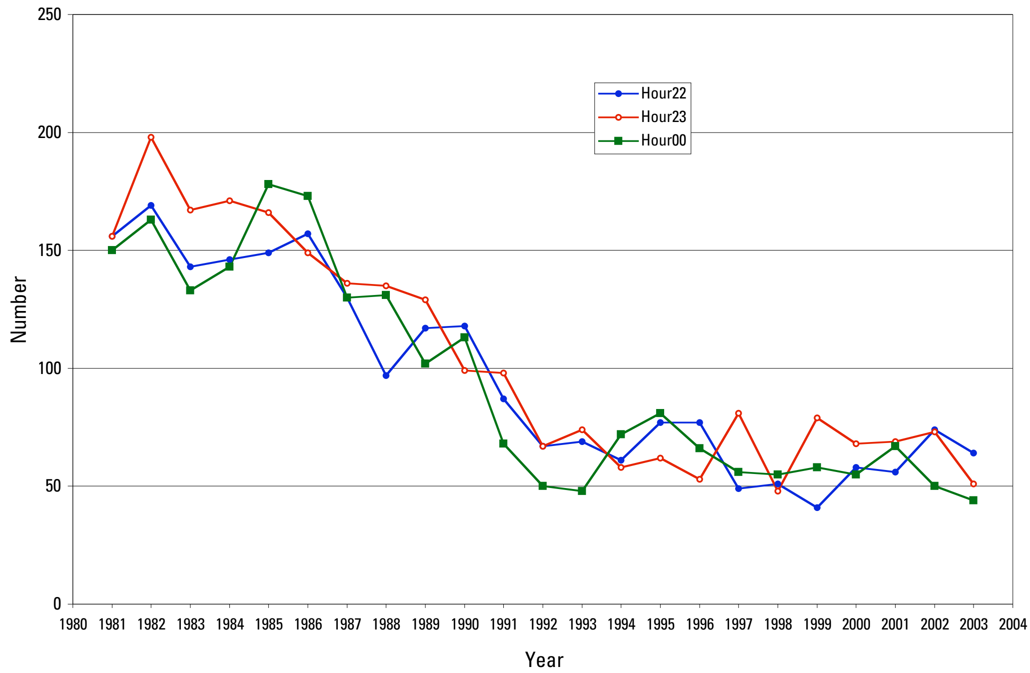

Figure 18. Casualties (fatal and hospital-admitted only) between the hours of 10 pm and 1 am: comparison of hours beginning 22:00, 23:00, and 00:00.

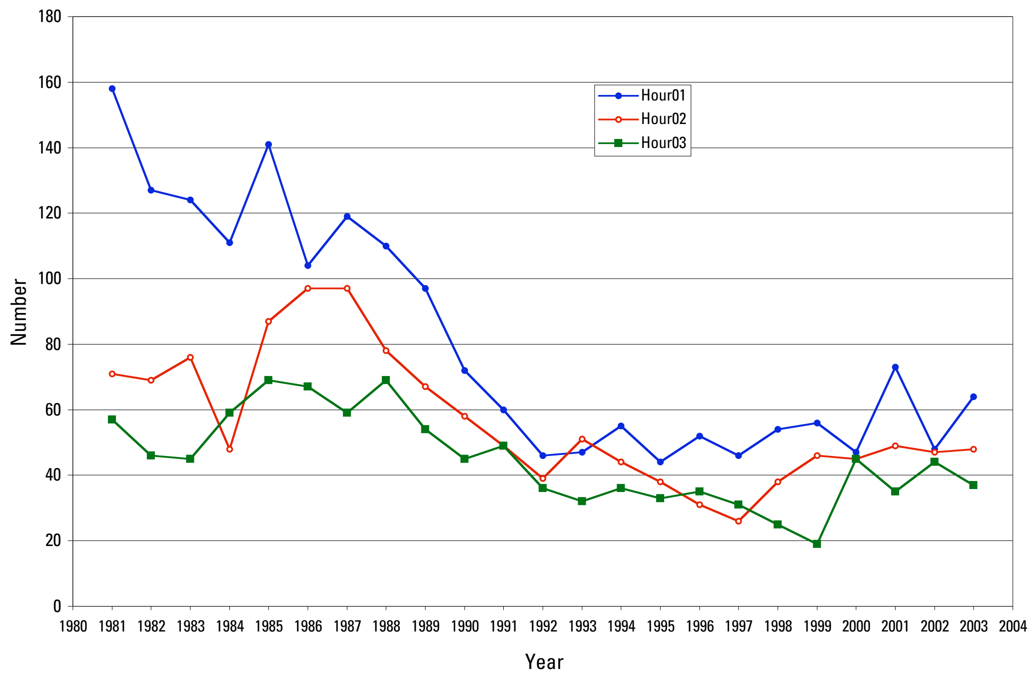

Figure 19. Casualties (fatal and hospital-admitted only) between the hours of 1 am and 4 am: comparison of hours beginning 01:00, 02:00, and 03:00.

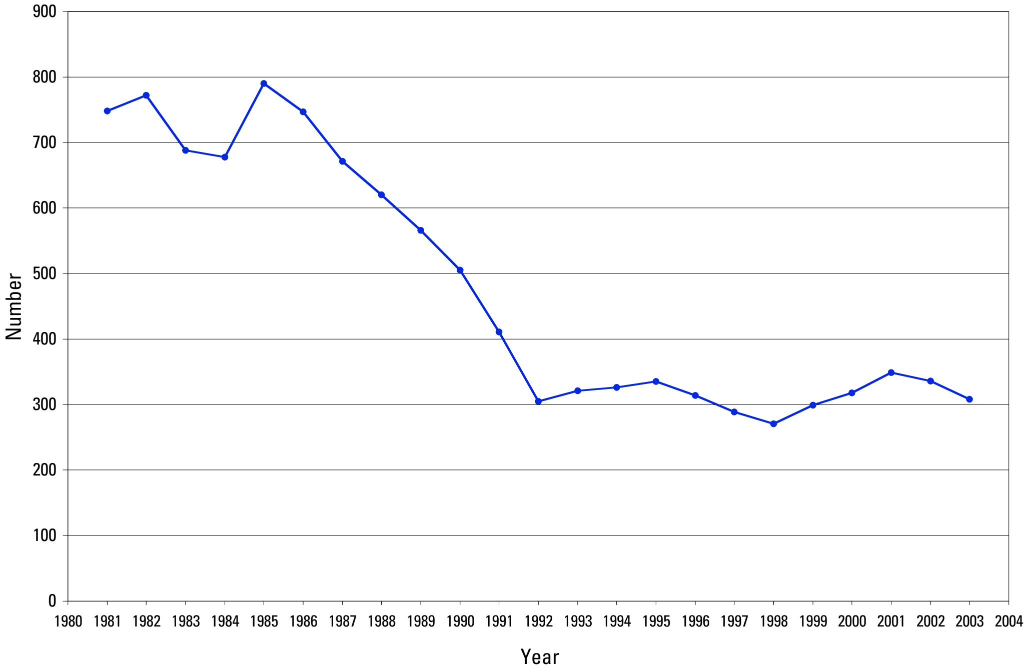

Figure 20. Casualties (fatal and hospital-admitted only) between the hours of 10 pm and 4 am.

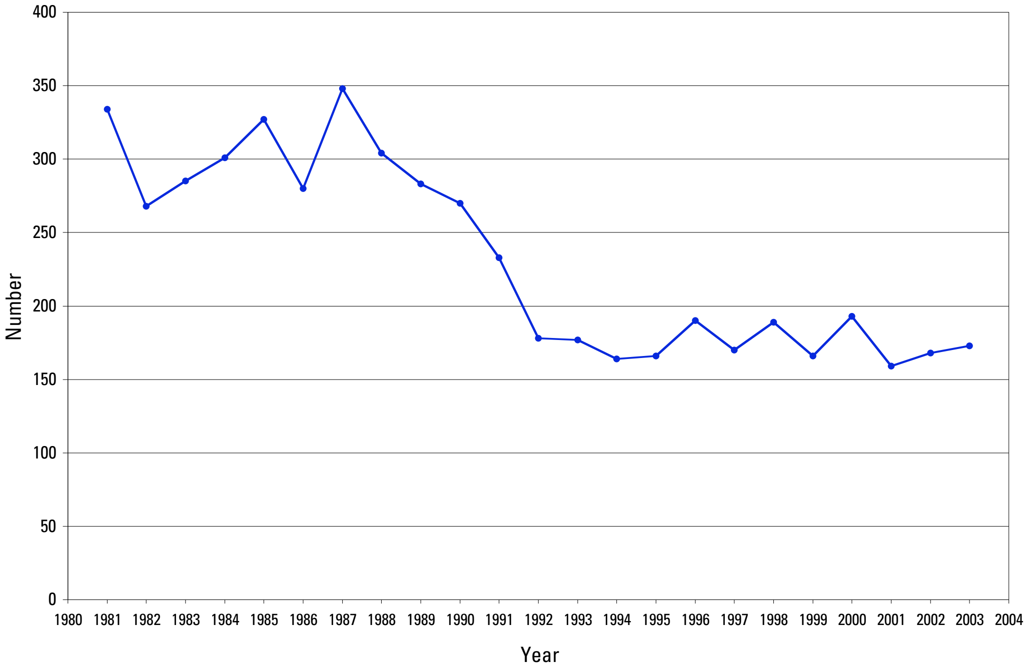

Figure 21. Casualties (fatal and hospital-admitted only) between the hours of 7 am and 10 am.

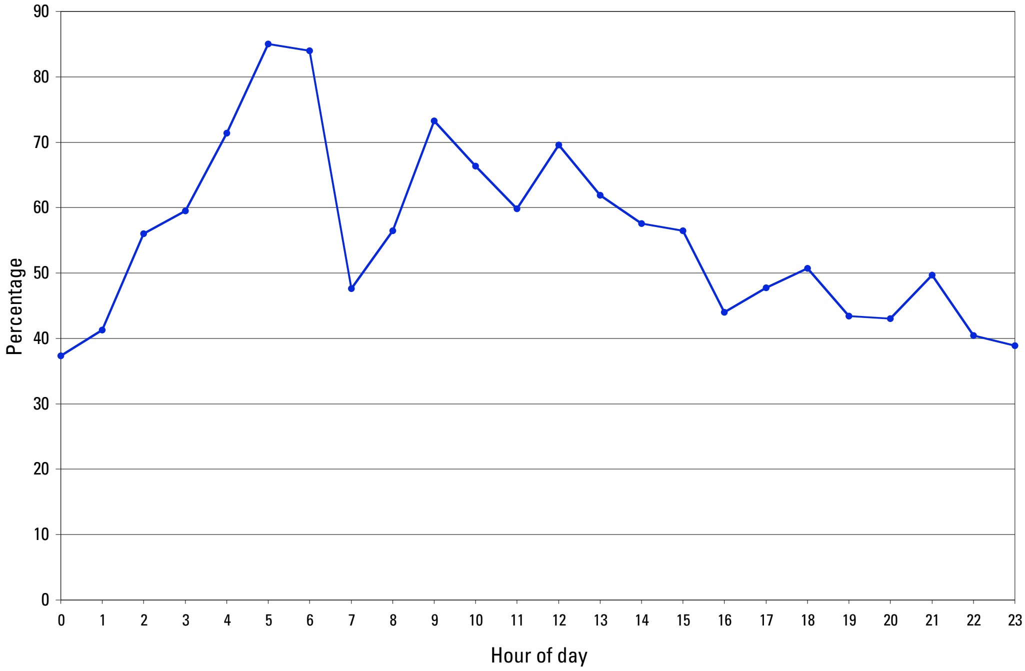

Figure 22. The number of casualties (fatal and hospital-admitted only) from 1992-2003 (averaged) expressed as a percentage of that from 1981-1986 (averaged), according to hour of day. (Hour 0, for example, refers to the period from 00:00 to 00:59.)

6.3 Child pedestrians

The number of child pedestrian casualties has been falling much more sharply than the number of adult pedestrian casualties. From Figure 23, it appears that the trend since 1994 has been much the same as that before. The same data is also plotted in Figure 24, but now as percentages of the numbers in 1981. It can be seen that approximately the same proportionate reduction is occurring for all three age groups. From 1981 to 2003, there was a reduction in the number of children in the population, but of much too small a magnitude to explain the reduction in casualties. Figure 44 below will express the data as rates, i.e., child pedestrian casualties per 100000 children.

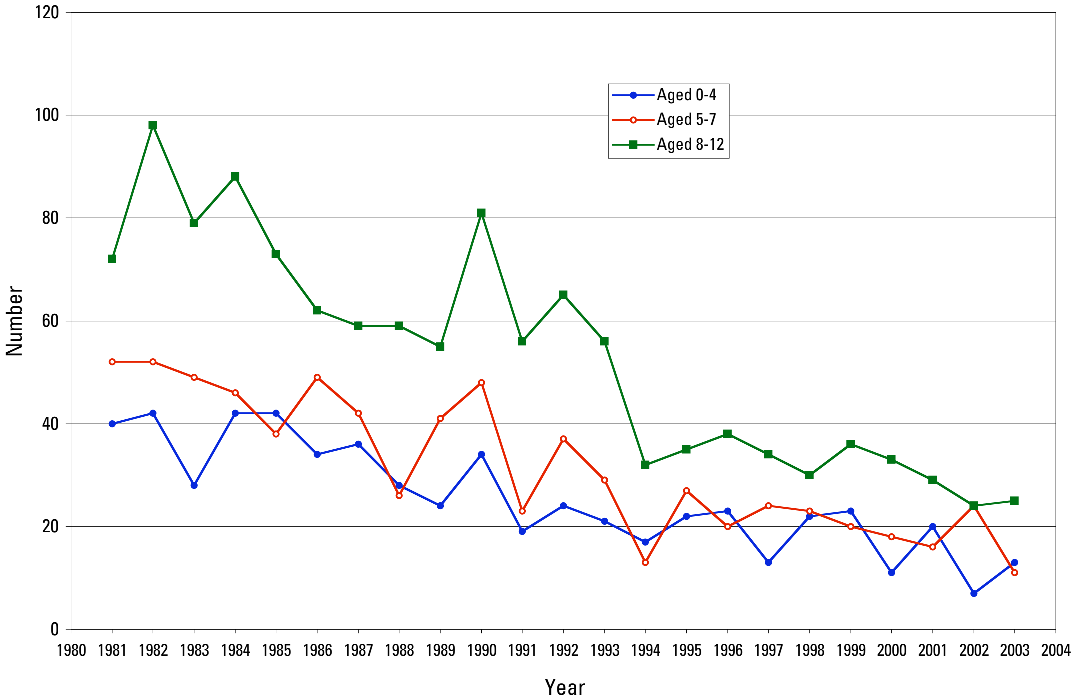

Figure 23. Child pedestrian casualties (all severities): comparison of age groups 0-4 years, 5-7 years, and 8-12 years.

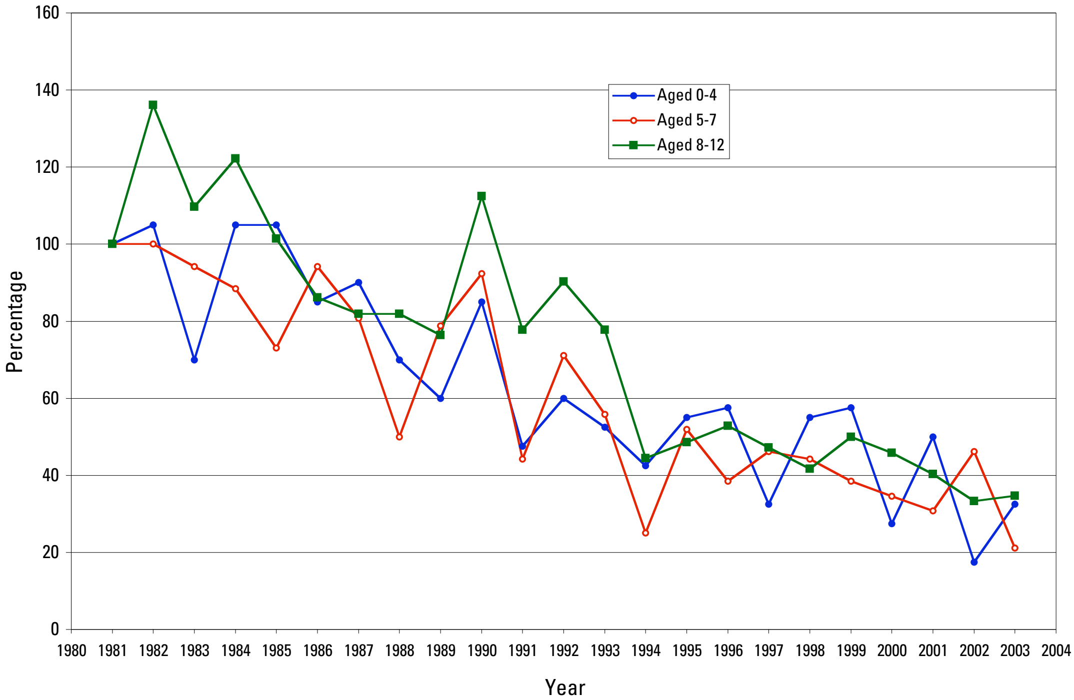

Figure 24. Child pedestrian casualties (all severities): as Figure 23, but expressed as percentages of the numbers in 1981.

6.4 Teenaged drivers

In Figure 25 there is an indication that the number of (fatal or hospital-admitted) teenaged driver casualties may have been rising in recent years, in both Adelaide and country areas.

This example provides quite a good illustration of the limitations of statistical testing. Suppose we ask, is the increase in recent years statistically significant (at the .05 level of significance)? If we conduct the test on the statewide figures (i.e., Adelaide and country areas combined, not shown in the Figure), the answers are as follows.

- the period 1990-2003: no
- the period 1991-2003: no
- the period 1992-2003: yes
- the period 1993-2003: yes
- the period 1994-2003: no
- the period 1995-2003: no

Thus if we carefully choose a period of years, we can find a statistically significant result. But, of course, selecting data so that a statistically significant result is obtained is not a valid procedure to follow. And there is further scope for finding results whose statistical significance may be spurious by considering the Adelaide and country data separately, by considering fatalities alone, by considering all levels of severity, by considering night-time crashes only, and so on.

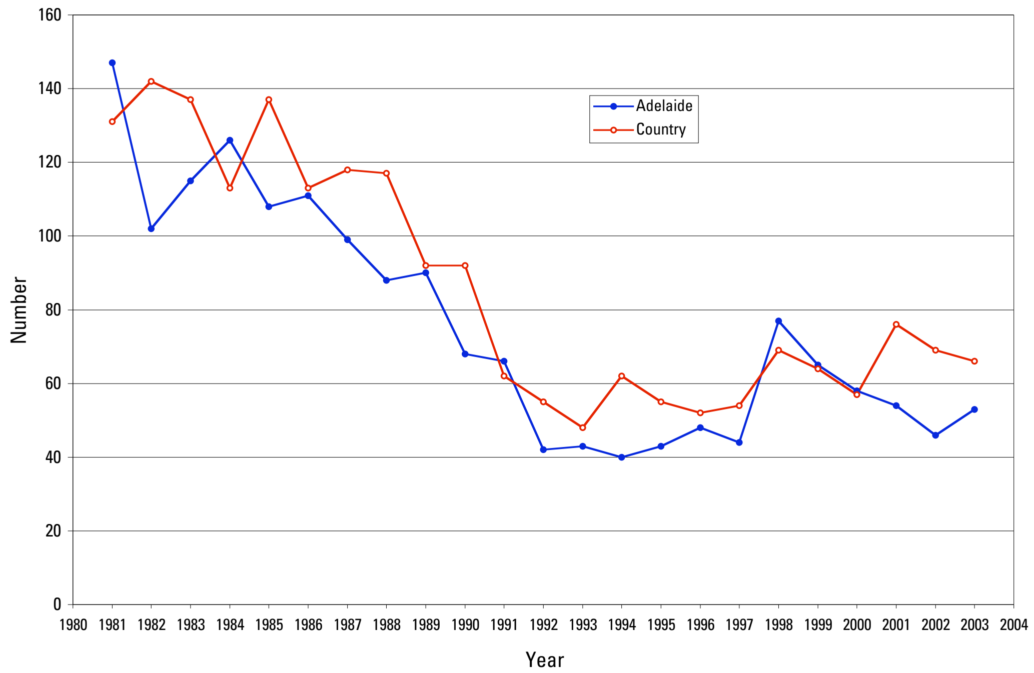

Figure 25. Teenaged car driver casualties (fatal and hospital-admitted only): comparison of Adelaide and country areas.

6.5 Motorcyclists

It appears from Figure 26 that the number of (fatal or hospital-admitted) motorcyclist casualties has been approximately steady in recent years, in both Adelaide and country areas.

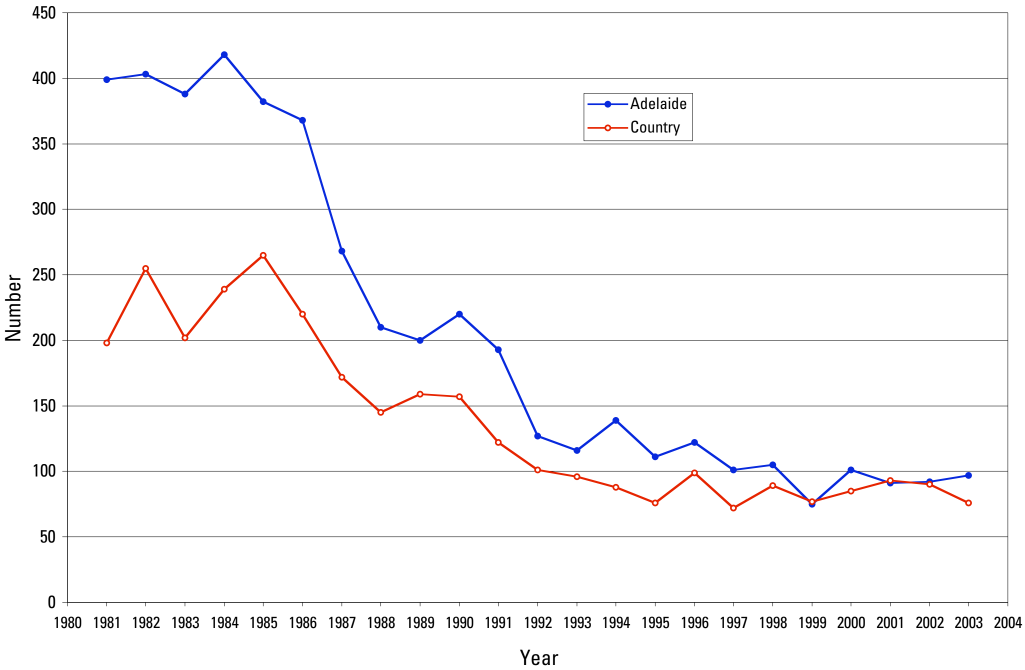

Figure 26. Motorcyclist casualties (fatal and hospital-admitted only; riders and passengers): comparison of Adelaide and country areas.

6.6 Truck drivers

The numbers are few (and therefore particularly variable). Thus it is difficult to draw any firm conclusions from Figure 27 about the number of truck driver casualties.

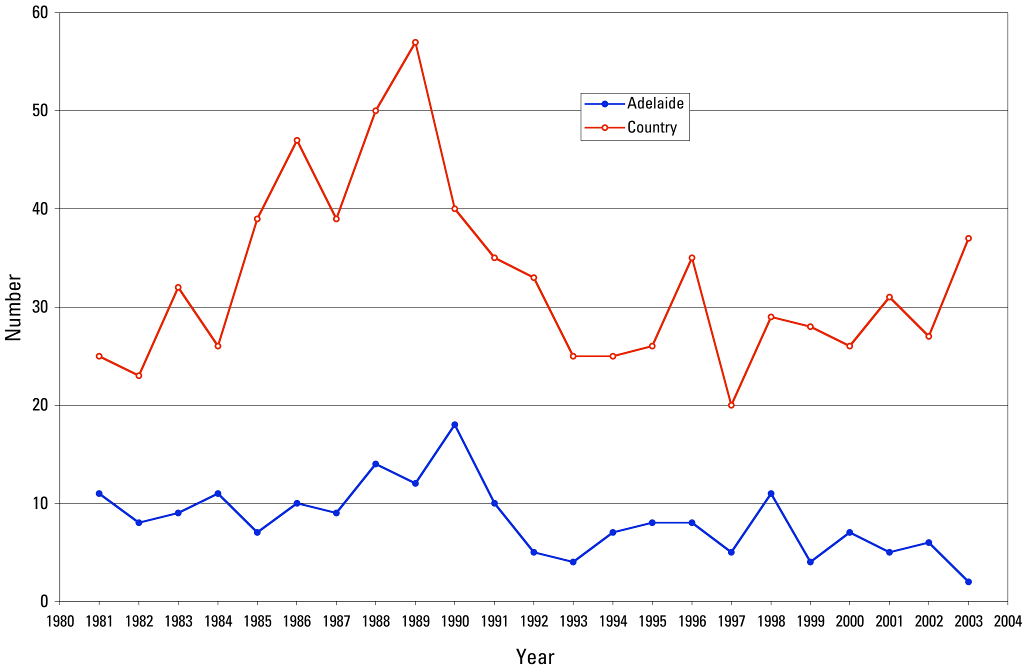

Figure 27. Truck driver casualties (fatal and hospital-admitted only): comparison of Adelaide and country areas.

6.7 Persons aged 65-84

Figures 28 and 29 refer to casualties (fatal or admitted to hospital) of all types, aged 65-74 and aged 75-84, respectively. The pattern of a sharp reduction from about 1986 to about 1992, preceded and followed by steady numbers, does not appear here. For the 65-74 age group (Figure 28), there seems to have been a steady reduction throughout the period 1981 to 2003, more marked in Adelaide than in country areas. For the 75-84 age group (Figure 29), the numbers for Adelaide have been fairly static, whereas the numbers in country areas have increased slightly.

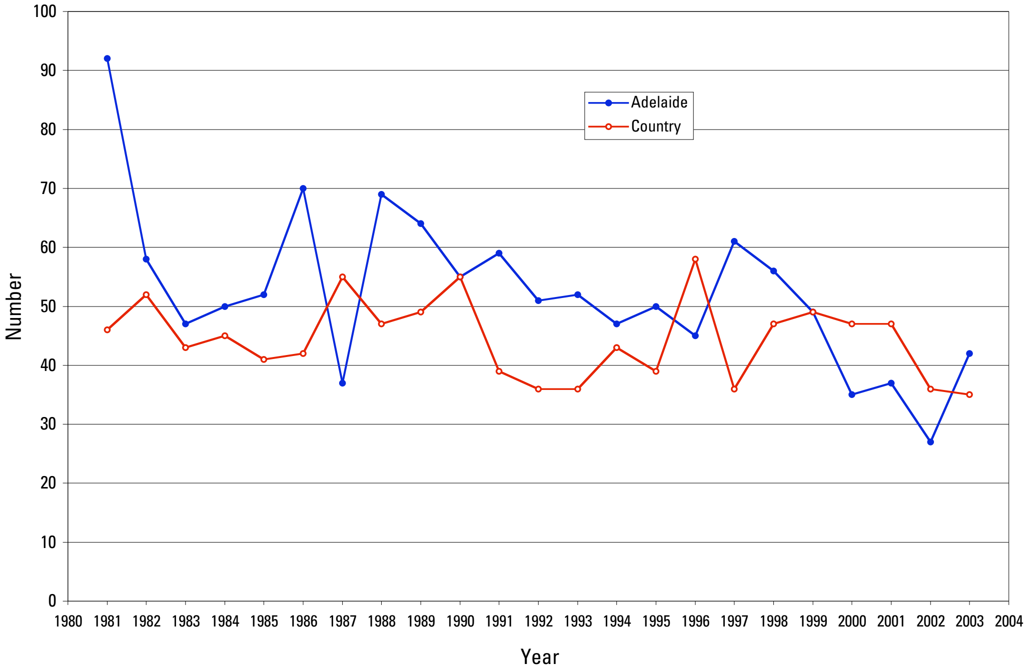

Figure 28. Casualties aged 65-74 (fatal and hospital-admitted only): comparison of Adelaide and country areas.

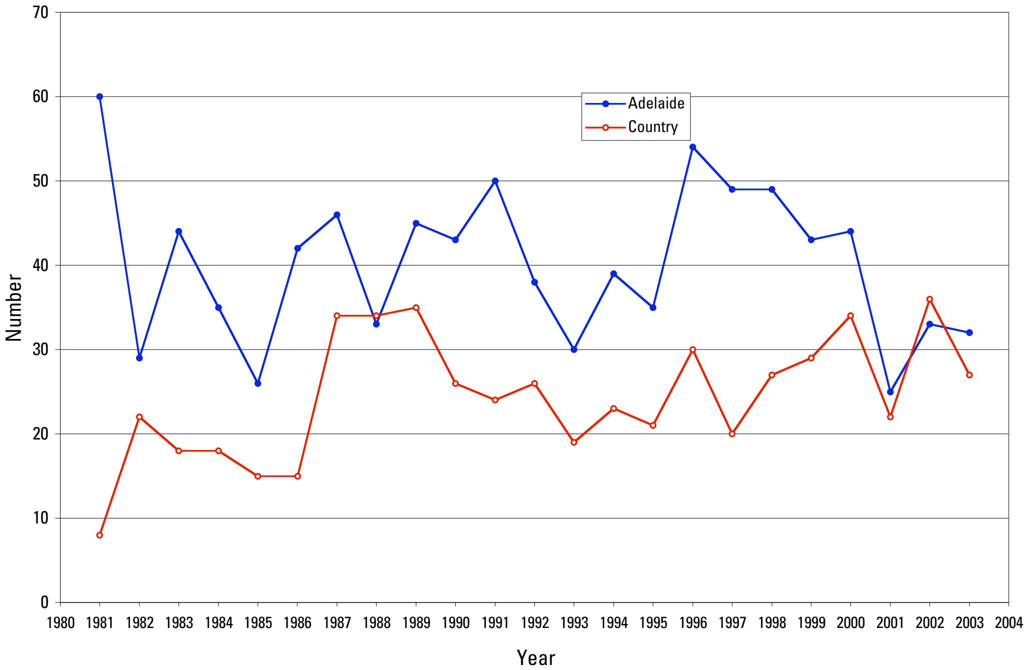

Figure 29. Casualties aged 75-84 (fatal and hospital-admitted only): comparison of Adelaide and country areas.

6.8 Car occupants, according to speed limit

Figure 30 appears to show that the sharp reduction in (fatal and hospital-admitted) casualties that occurred around 1990 was more pronounced in areas with a 60 km/h speed limit than in areas with a higher speed limit. This is clearer in Figure 31, which indexes the numbers to a baseline of 1981 = 100. Note, however, that the proportions of vehicle kilometres that are driven on roads having different speed limits may have changed substantially over the years.

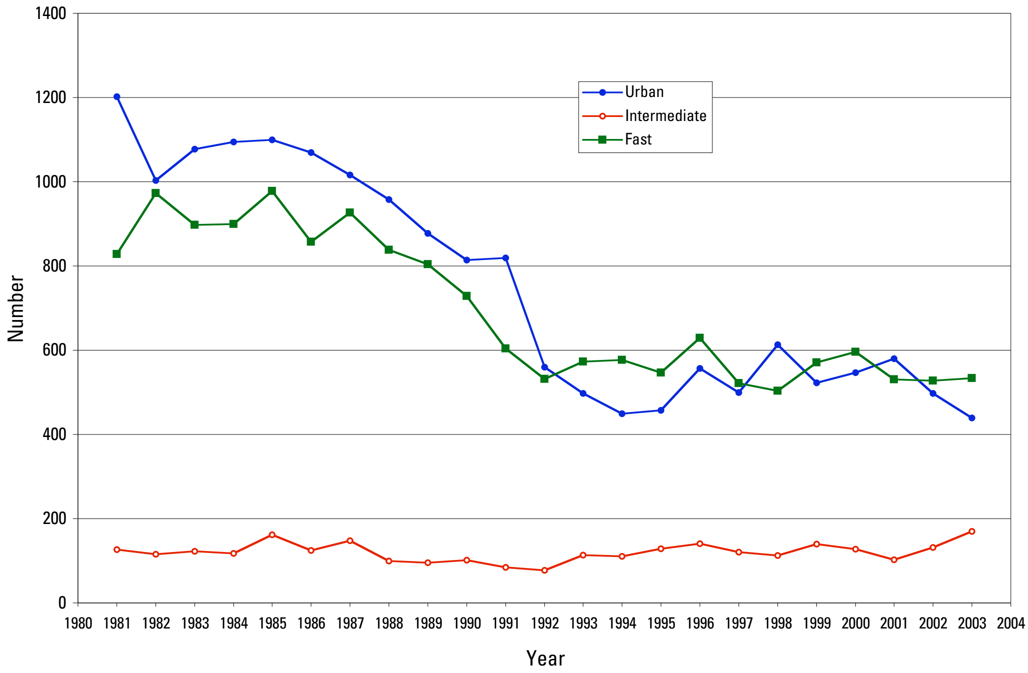

Figure 30. Car occupant casualties (fatal and hospital-admitted only): comparison of different speed limit areas (urban refers to a speed limit of 60 km/h, 50 km/h, or 40 km/h, intermediate refers to 70 km/h or 80 km/h, and fast refers to 90 km/h, 100 km/h, or 110 km/h).

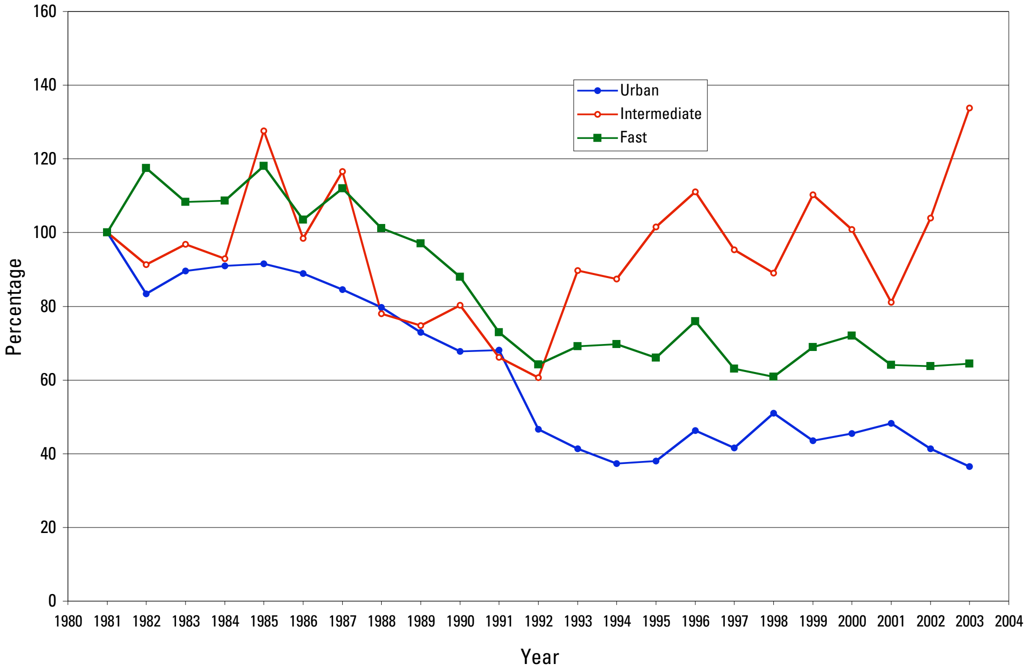

Figure 31. Car occupant casualties (fatal and hospital-admitted only): as Figure 30, but expressed as percentages of the numbers in 1981.

6.9 Comment on the trends in casualty numbers in different categories

Considering the set of time series that have been plotted above, it seems fairly clear that different categories and sub-categories of casualty show different patterns in the way the numbers have evolved. This should be no surprise, in view of the remarks made in the Introduction.

The concern that prompted this project might be rephrased: are there any categories of accident that are not falling, what are they, and why? To answer the "why" would be to go beyond the scope of this project, but several points can be made in response to the other parts of the question. Concern is justified in respect of the following.

- The more minor categories of crash (i.e., PDO, treated by doctor, and treated at hospital), see Figure 3.
- Rear-end crashes of low severity, see Figure 5.
- As regards the more minor categories of injury, the Adelaide metropolitan area is doing worse than country areas, see Figures 9 and 10.
- Drivers, as contrasted with other categories of road user, are increasing as a proportion of the total number of fatal and hospital-admitted casualties, see Figure 17.
- The number of fatal and hospital-admitted casualties aged 75-84 is increasing in country areas, see Figure 29.

7 Comparison of other datasets with TARS

TARS statistics, like all routine statistics everywhere, are sure to be contain errors. (As mentioned earlier, there are discussions of some aspects of errors in road crash statistics in Hutchinson, 1987, and O'Connor, 2002.) It is sensible, therefore, to try to check data from TARS against data from other sources. In most respects, that is not possible, because other sources are not as detailed. But some checks concerning totals numbers of casualties are possible.

7.1 Fatalities: Comparison of statistics from the death registration process with TARS

Statistics on road accident deaths are available based on death certification by a doctor and registration by an arm of government (the Births, Deaths and Marriages Registration Office or similar authority), as well as from the police. (For an international perspective, see Hutchinson, 1987, especially Chapter 9.) Australian data may be found at www.nisu.flinders.edu.au/data/phonebook/phbkmain.php, which is the website of the Research Centre for Injury Studies, Flinders University. Figure 32 compares the two time series of totals. They are within a few per cent of each other. Figure 33 shows the ratio of the two: only in a few years is this as small as 0.90 or as large as 1.10.

Listed below are some known reasons why the numbers of deaths as recorded by the two systems differ.

- As in many other jurisdictions, the police data include only deaths within 30 days of the accident. The registration process does not have this requirement.
- The police data refer to the year in which the accident took place, whereas the registration process refers to the year in which the death was registered.
- An accident occurs in another State, but the person dies in South Australia, or vice versa.
- Differences in the scope of accidents included (e.g., relating to definitions of public highway and motor vehicle).

(The two most important are the first two; the others probably only occur rarely.) The 30 day limit for the police data will lead to an undercount relative to the registration data. It is thus surprising that the ratio in Figure 33 exceeds 1.00 more often than not.

Figures 34-38 compare the police and death registration data for different categories of casualty.

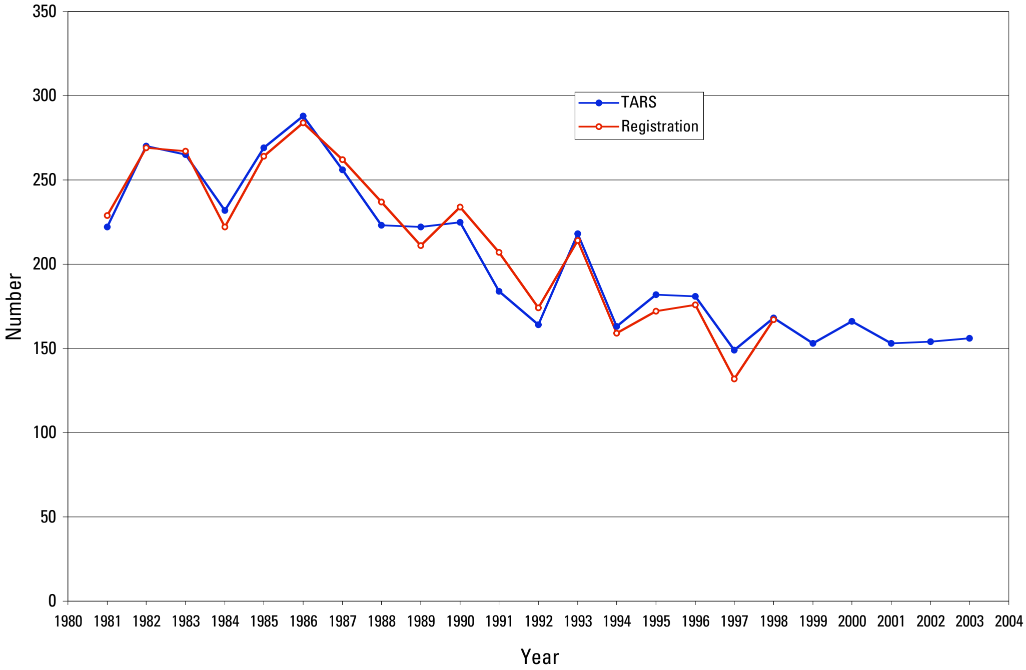

Figure 32. Fatalities: comparison of the numbers according to TARS and according to the death registration process.

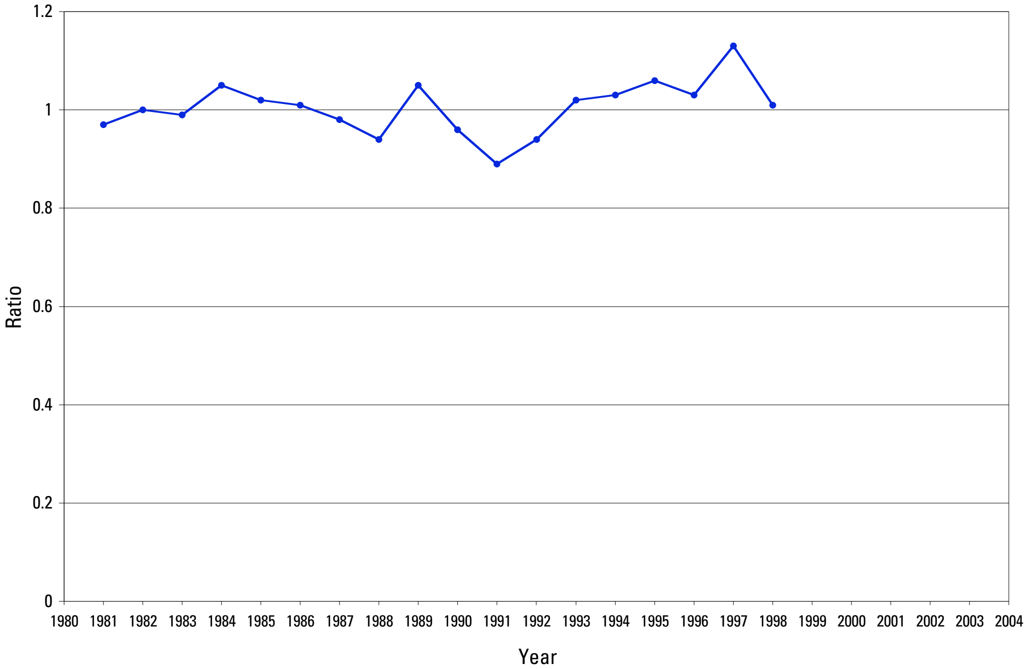

Figure 33. Ratio of total fatalities according to TARS and according to death registration.

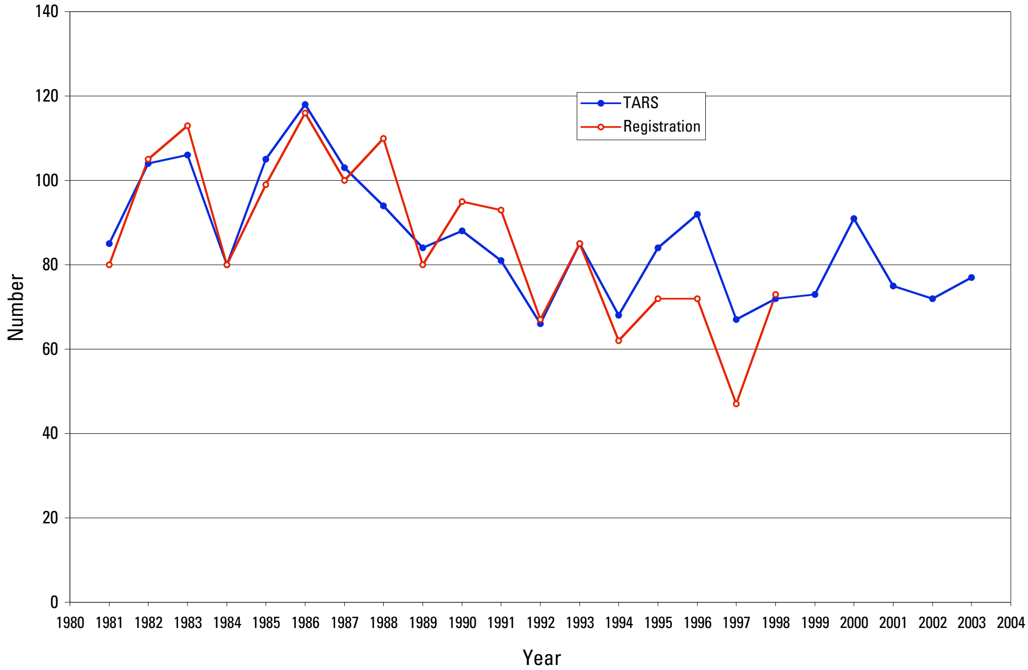

Figure 34. Driver fatalities, according to TARS and according to the death registration process.

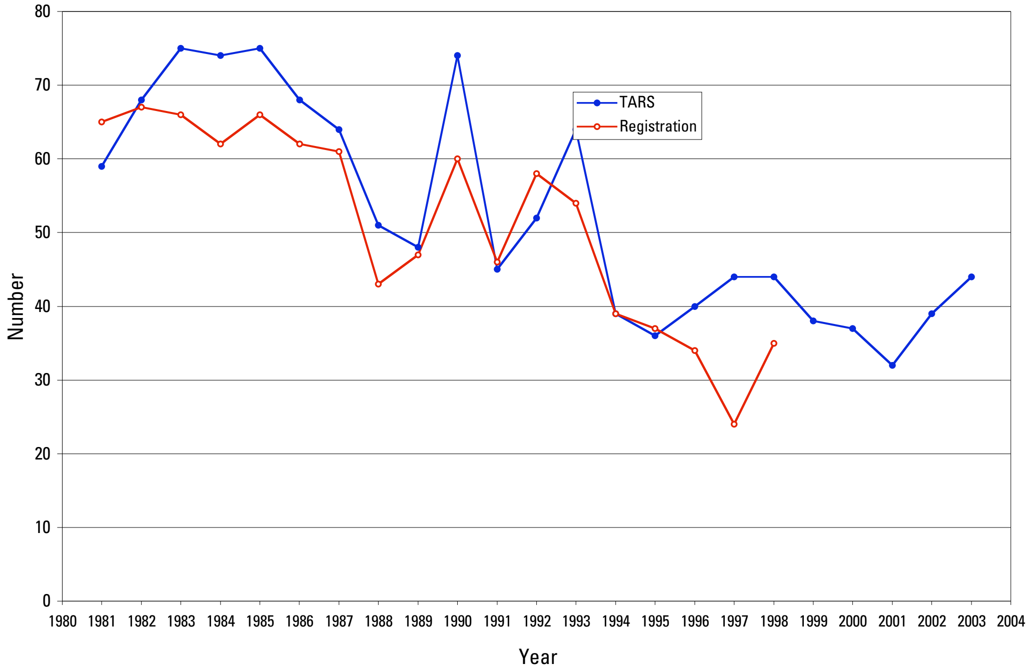

Figure 35. Passenger fatalities, according to TARS and according to the death registration process.

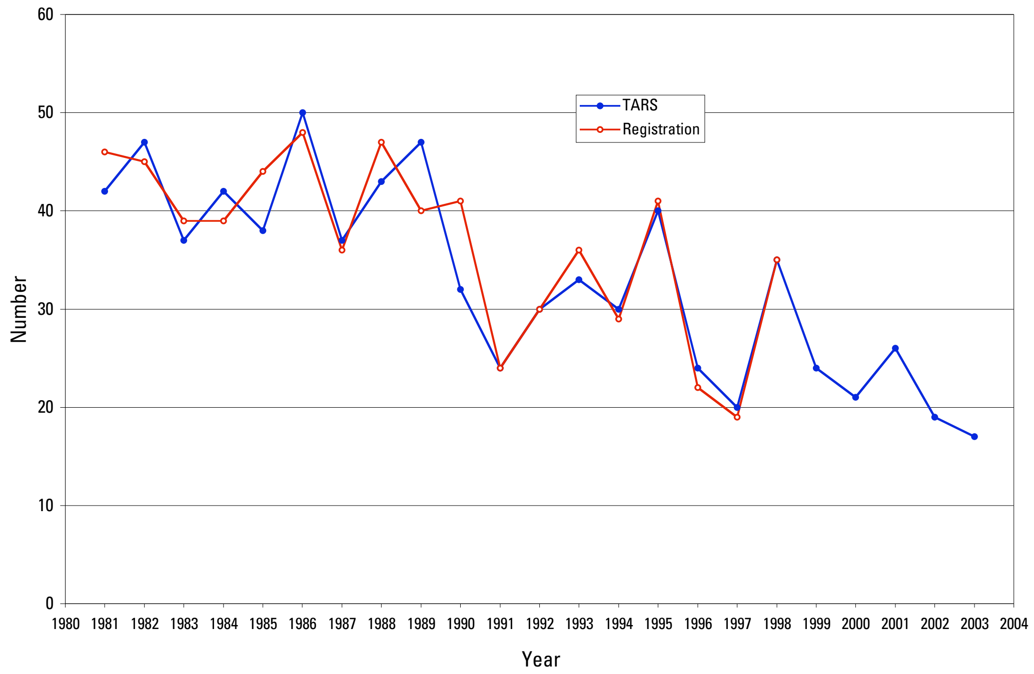

Figure 36. Pedestrian fatalities, according to TARS and according to the death registration process.

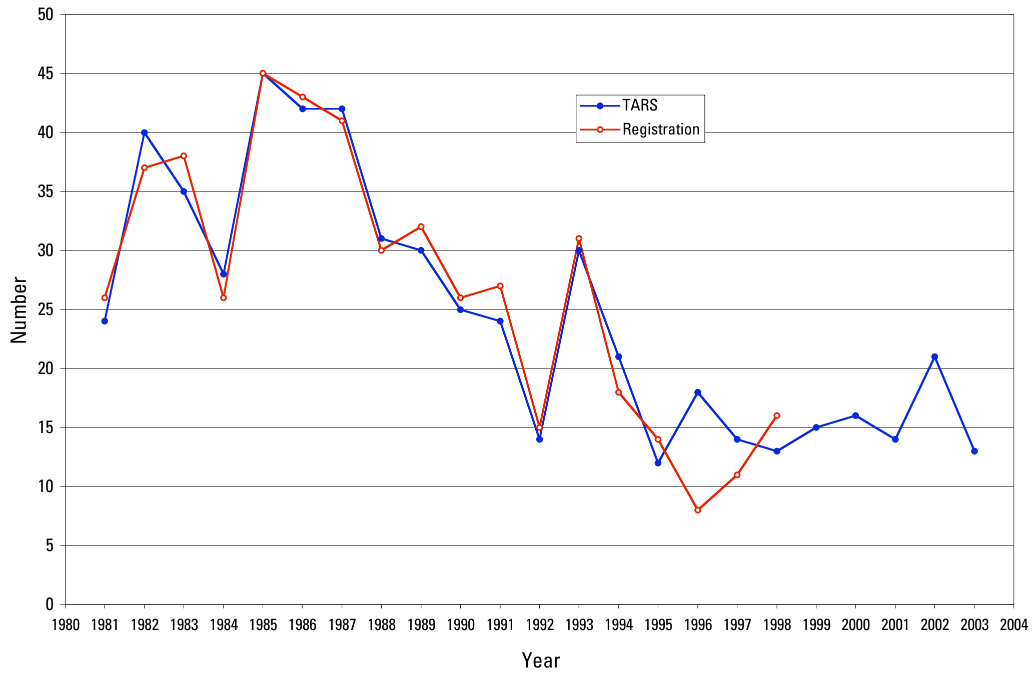

Figure 37. Motorcyclist fatalities (including both riders and passengers), according to TARS and according to the death registration process.

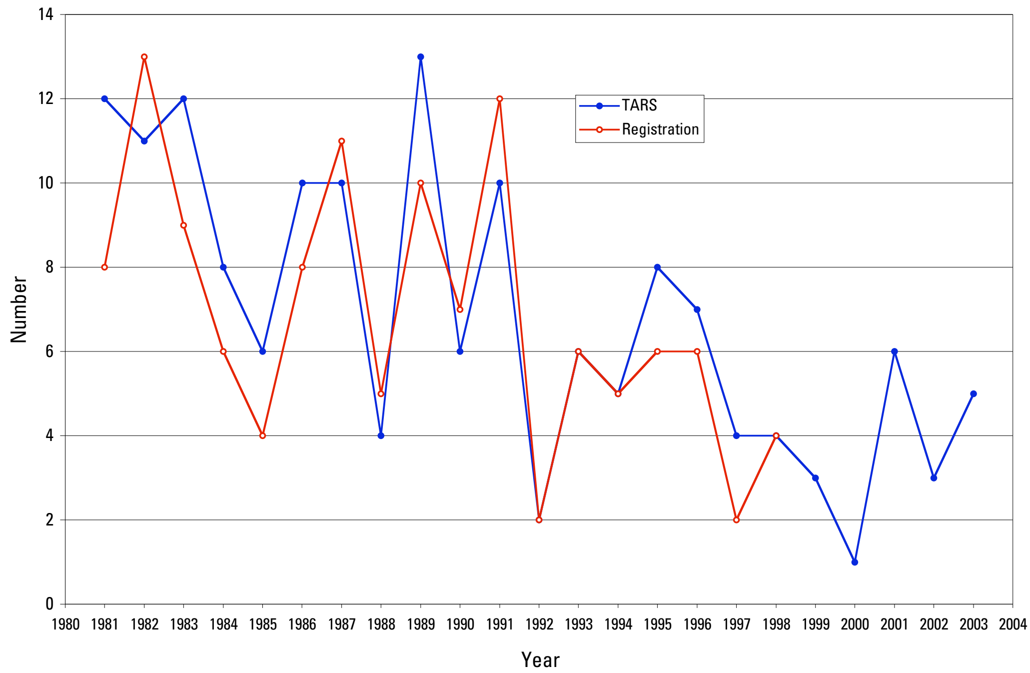

Figure 38. Pedal cyclist fatalities, according to TARS and according to the death registration process.

7.2 Nonfatal injuries: Comparison of hospital separations data with TARS

Statistics on road accident casualties are available from hospital in-patient statistics systems, as well as from the police. For an international perspective, see Hutchinson, 1987, especially Chapter 10. For data and discussions of the situation in Australia in 1990-1991, see FORS (1993, 1995).

The admitted patient morbidity system in South Australia is known as ISAAC (Integrated South Australian Activity Collection). Thanks to Dr Ron Somers of the Injury Surveillance and Control Unit, SA Department of Human Services, we have tabulated the numbers of hospitalised victims of motor vehicle traffic accidents recorded by ISAAC in the calendar years 1988-2002. (The hospital statistics were recorded using the 9th Revision of the International Classification of Diseases up to mid-1999, and using the 10th Revision from mid-1999 onwards. There is thus a possibility that the figures from 1999 onwards should not be compared with those from earlier. However, there is no reason to think that the effect of the change was numerically anything other than very small.)

The two time series of numbers hospitalised are compared in Figure 39. The numbers according to TARS are much less than the numbers according to ISAAC --- some 56 per cent, on average. They have evolved similarly over time: if there is a feature of difference, it is that the hospital data indicate a slight decline in numbers over the period 1992-2002, whereas the TARS data indicate virtually no decline over this period. Figures 40 and 41 present the same data in slightly different ways: Figure 40 shows the data indexed to 1988 = 100, and Figure 41 shows the ratio of TARS to ISAAC numbers.

A few minor points about Figure 39 should be noted. The numbers are of casualties, unlike Figure 2, which referred to crashes. The number of hospital-treated casualties according to TARS is about three times the number of hospital-admitted cases, so including these would give a substantial overcount of the numbers according to ISAAC. The ISAAC numbers include cases who were admitted to hospital but died.

The present report is concerned with TARS data, with Figures 39-41 being given largely as a check, and detailed discussed of hospital statistics on road casualties would be out of place. Nevertheless, it may be noted that O'Connor (2000) drew attention to the substantial undercount of hospitalised casualties in the police statistics, and quoted approvingly a Federal Office of Road Safety report that said "hospital records are the better data source for describing the overall extent of road crash hospitalisation and the basic demographics of those hospitalised". See FORS (1995), and there was a similar statement in FORS (1993); but subsequent editions of that publication seem to have been based on police statistics only. One of the present writers was an early user of such data (Hutchinson and Harris, 1978), and for the most part we agree with such sentiments. Nevertheless, it is plain from Chapters 9-12 of Hutchinson (1987) that there are many puzzles in routine data about deaths and hospitalisations from road accidents.

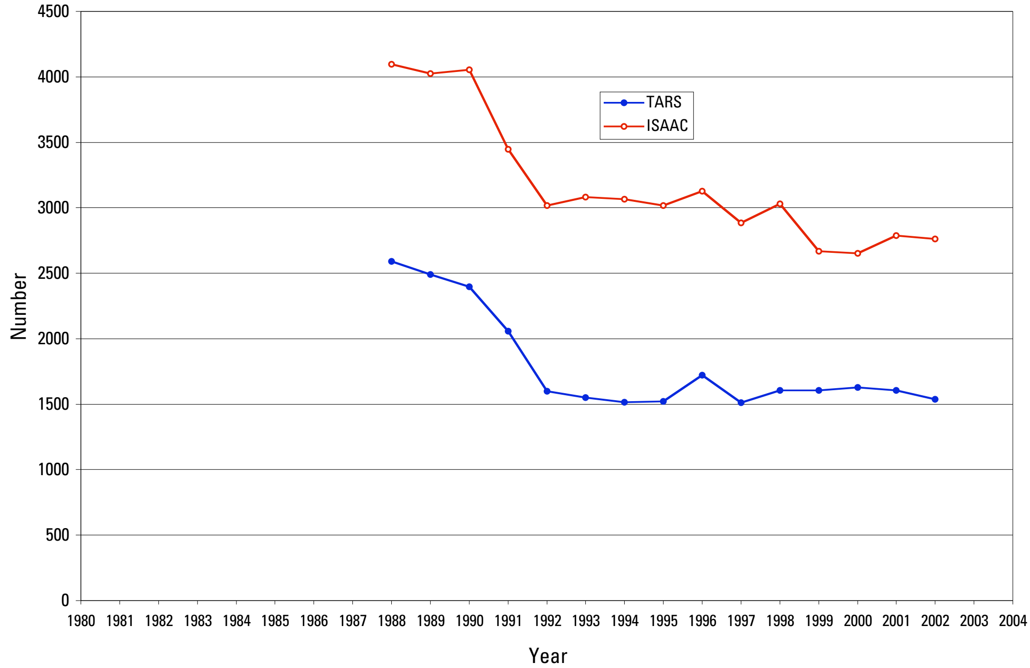

Figure 39. Hospitalised casualties, according to TARS and according to ISAAC (the hospital in-patient statistics system).

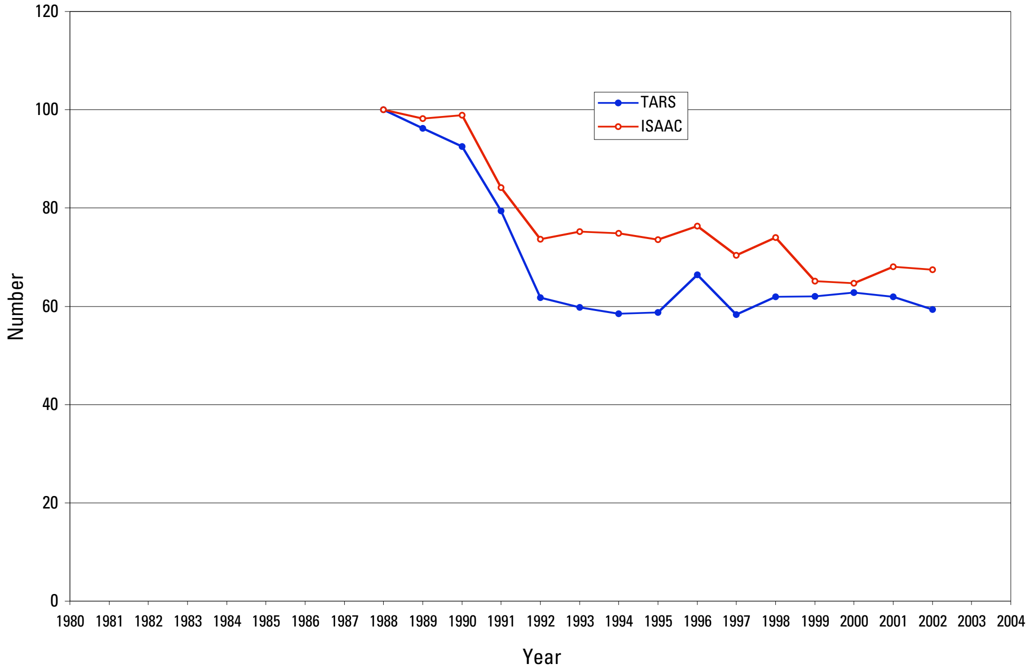

Figure 40. As Figure 39, but expressed as percentages of the numbers in 1988.

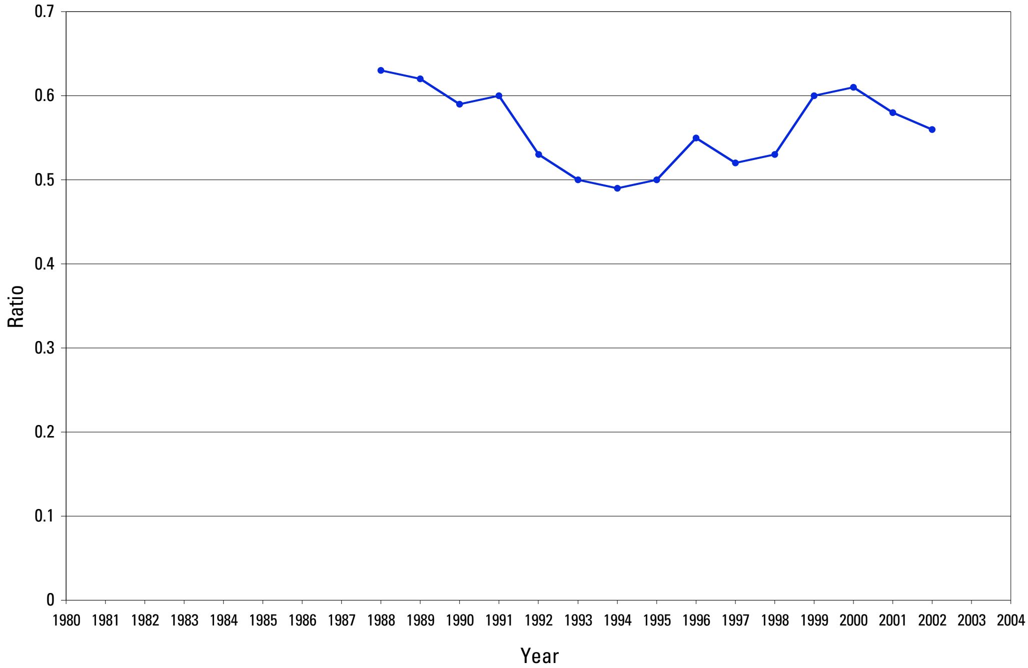

Figure 41. Ratio of hospitalised casualties according to TARS and according to ISAAC (the hospital in-patient statistics system).

7.3 CTP claims

Some interesting comparisons between CTP (Compulsory Third Party) insurance claims and the TARS casualty data were made by McColl (2003). The finding most relevant to the present context concerns the trends over recent years (1998 to 2002) revealed in the two sources. McColl points out that many (approximately 41 per cent) of the claims are not included as casualties the TARS data, and vice versa. Thus if the total numbers are very similar, as indeed they are, it is coincidental. Nevertheless, it is noteworthy that the (fairly small) changes over that time period were similar in the two datasets.

Hutchinson (1987, Chapter 14) discusses insurance claims data, especially from the United States, Australia, Sweden, and Japan. Hutchinson notes that among the advantages of insurance data are its volume (many insurance claims are made for crashes that are not reported to the police), the inclusion of PDO cases, information about vehicle characteristics such as make and model being known, and injury descriptions being frequently better than in police data. The disadvantages are the time that elapses between the accident and making the claim (and thus the scope for inadvertent distortions of recollection), and the deliberate distortions that may be introduced by the claimant.

8 Macroscopic economic and social independent variables

There exists a body of research that attempts to relate the number of accidents to indicators of economic activity. See Appendix 1 of Harry (1997) for discussions of fifteen overseas and eight Australian papers.

One idea that recurs is that in economic depressions, the accident numbers might be fewer than usual and unemployment might be higher than usual, and thus over time a negative relationship between accident numbers and unemployment rate might be observed. At this point, consideration needs to be given to the reasons why accident numbers might be low when economic conditions are depressed. Firstly, there is the amount of travel. There may be more travel in good economic times, and less in bad. So it will be no surprise if there are more accidents in good economic times. Secondly, there are other reasons. The purposes of trips may be different in different economic conditions (e.g., there may be less leisure travel in bad economic times), and different purposes may be associated with different accident rates. More speculatively, style of driving may be related to economic conditions, e.g., driving may be faster in good economic times, because of less concern with fuel economy or because of some psychological feeling. The first of these reasons (amount of travel) is very plausible, and thus it seems pointless to try to relate accident numbers to (say) unemployment rate, and more appropriate to work in terms of accident rates.

8.1 Accident rates

As to quantities that might be used to standardise the accident or casualty numbers (i.e., convert them into rates), probably the most direct is the estimated distance driven by all vehicles in the State in a year. If this is available, less direct quantities such as the population of South Australia, or the number of registered vehicles, will not be needed. Estimates of the vehicle kilometres travelled in South Australia are indeed available for some years (1982, 1985, 1988, 1991, 1995, 1998, 1999, 2000, 2001, 2002). For these figures, see Table 16 of ATSB (2003). (There is a note there that the survey methodology changed in 1998.) They indicate an average annual rate of increase of 1.5 per cent.

The rate of accidents per hundred million vehicle kilometres has been calculated, and the time series is plotted in Figure 42. The fatality rate is seen to decline fairly steadily from 1982 to 2002. Thus it seems quite possible that the failure to reduce fatalities since about 1994, that was evident in Figure 1, is a reflection of the growth in vehicle kilometres. When a logarithmic scale is used (Figure 43), it is even more difficult to perceive any flattening. In other words, the yearly proportionate reduction in fatality rate has not changed greatly from 1981 to 2003. Other than this, there is not much further to add to the message in Figure 1.

An alternative to using vehicle kilometres travelled to standardise the number of casualties would be to use the number of people. One of the largest changes evident in the graphs presented earlier was the fall in child pedestrian casualties (Figure 23): could this be due to there being fewer children now than in 1981? No, the decline in numbers of children has been much too small to be an explanation. From 1981 to 2003, the numbers of children in age groups 0-4 years, 5-7 years, and 8-12 years respectively decreased by 4 per cent, 4 per cent, and 12 per cent. Figure 44 shows the trends in the ratios of casualties to the population in the relevant age group: the picture of continuing reduction is similar to that in Figure 23. Of course, since the rate is based upon population, not on distance walked or time spent in the vicinity of roads, if children walk to school less frequently now than they did in the past, or play in the road less frequently, this would contribute to the reduction shown in Figures 23 and 44.

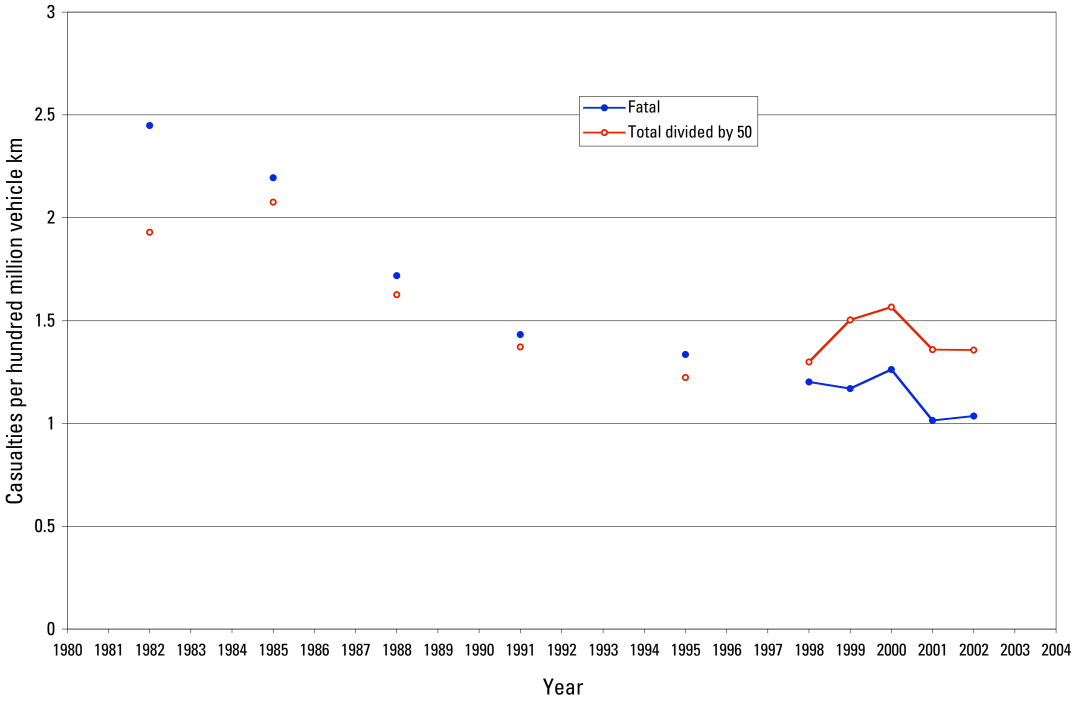

Figure 42. As Figure 1, but expressed as rates per hundred million vehicle kilometres. (Data on vehicle kilometres travelled were only available for some years.)

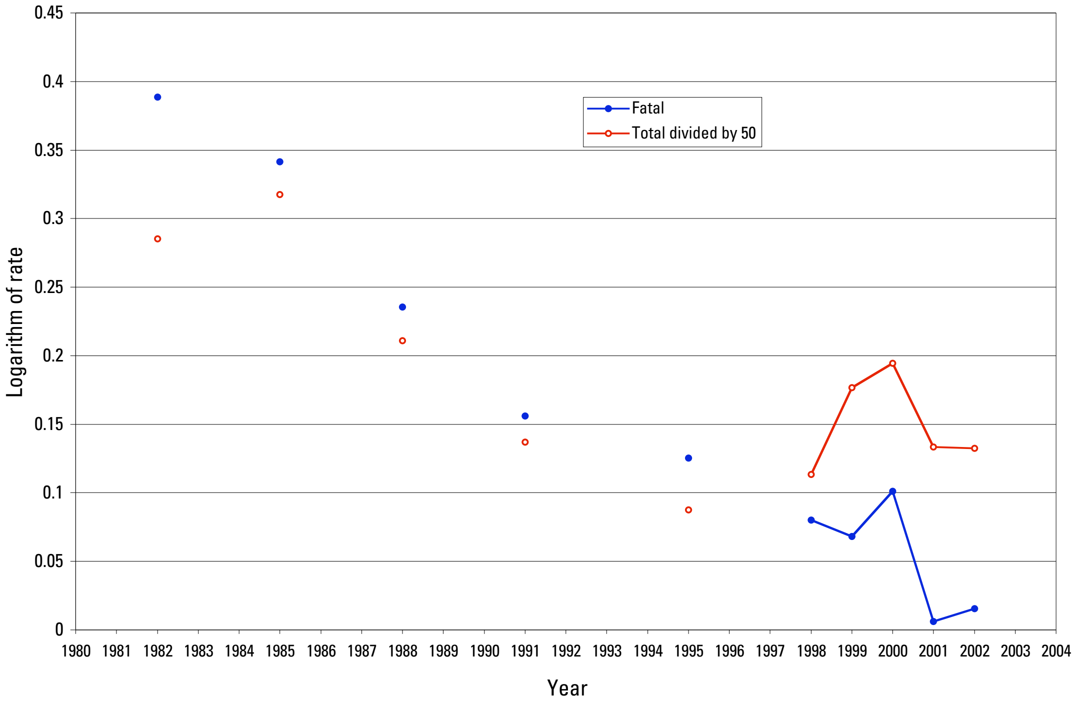

Figure 43. As Figure 42, but using a logarithmic scale for the casualty rates.

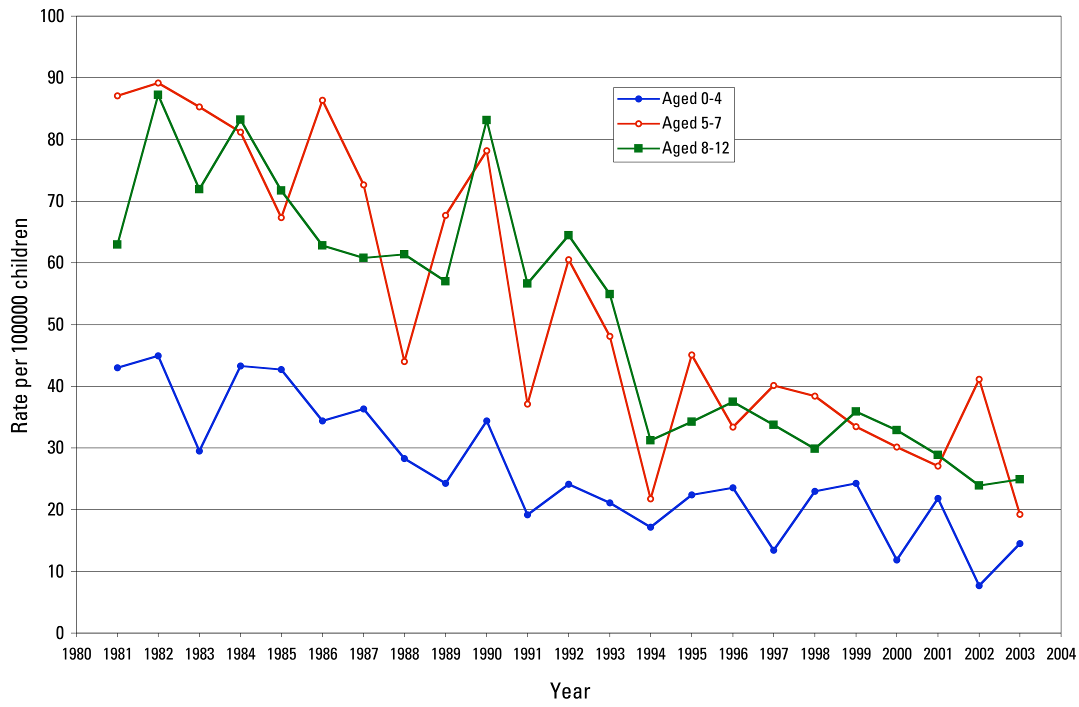

Figure 44. Child pedestrian casualties (all severities): as Figure 23, but expressed as rates per hundred thousand children.

8.2 Economic conditions or social climate

As indicated earlier, it has sometimes been suggested that such things as trip purposes and style of driving may vary with economic conditions, and be reflected in accident numbers. (See Harry, 1997, and references cited by her.) Full discussion of possible relationships between accident rates and variables that may summarise economic conditions, social climate, or public morale is beyond the scope of this report. Let us sketch the difficulties. There are many variables that might be considered, and great care would be needed in selecting them. As to the independent variable, many measures of economic conditions are correlated with total vehicle kilometres. As to the dependent variable, it presumably ought to be some sort of rate (rather than the accident number), but whether total vehicle kilometres (as used in Figure 42) is appropriate is not clear: many accidents occur when there is conflict between vehicles, and the dependence of conflicts on vehicle kilometres is likely to be stronger than linear. The hypothesis thus becomes: something similar to accidents divided by vehicle kilometres (but possibly subtly different from this) will be related to something that is not the same as vehicle kilometres (but may be highly correlated with it). This seems so vague as to be impossible to research at the level of state accident numbers. It is conceivable that at the level of the individual, some travel surveys might include relevant trip purpose data, or some spot speed surveys might include relevant data on chosen driving speeds.

Furthermore, there is a methodological issue. Consider the following two possibilities as to how the data might be treated.

- Relate y (accident rate) to x (economic activity).
- Relate year-on-year change in y to year-on-year change in x.

The first of these is of limited relevance: if y has been declining over time (as it has), and x has been increasing over time (as it has), there will be a high negative correlation between x and y. But this is likely to be dismissed as a spurious correlation obtained because there has been a time trend in both x and y. As to the second strategy, a likely problem is that year-on-year change in economic activity is bound to be a small fraction of total economic activity, and year-on-year change in accident rate is bound to be a small fraction of accident rate, and so random errors are likely to be relatively important. And adding to the difficulties will be the question, how much lag? That is, should we expect a change in accident rates to coincide with a change in economic activity, or will there be a delay between economic conditions and resulting behaviour? In any case, such a study cannot be based on annual data: the total vehicle kilometres was only estimated in some years, and thus accident rates are only available for those years.

As an example, Table 1 shows the average annual percentage increase in Gross State Product and the average annual percentage reduction in the fatalities per hundred million vehicle km, for three recent time periods. It is usually presumed that any relationship is likely to be a negative one (i.e., high economic growth will lead to the reduction in fatalities being slowed or reversed), but that does not seem to be the case with this dataset.

Table 1. Annual percentage increase in Gross State Product
and the average annual percentage reduction in the fatality rate in South Australia

Time period	GSP	Fatality rate
1991-1995	0.9	1.8
1996-1998	4.4	3.4
1999-2002	2.6	3.9

9 Conclusions

Some things have emerged fairly clearly.

- Although the number of fatalities has not fallen much since about 1992, this has been a result of a continued decline in the fatality rate and an increase in vehicle kilometres travelled.
- The increase in total casualties over the period 1992-2000 was largely confined to the minor categories of injury.
- An increase in minor rear-end crashes was part of this, but not all of it.
- In the metropolitan area of Adelaide, hospital-admitted casualties have been falling faster than fatalities over the period 1981-2003. (The evidence is less clear for country areas.)

It must be admitted, though, that there are numerous other features of the data that are not fully understood. In some cases, it is possible that a more elaborate tabulation of subcategory numbers would throw light on the issue (to do this would result in the present report becoming too long and detailed); in other cases, it is difficult to imagine resolving the issue with mass accident data.

A degree of anxiety over recent numbers and where the trends are heading is natural. Death and injury on the road is an emotional subject, even when, as in this report, dry statistics are examined. Each person is entitled to their own reaction, which will be different for someone focussing on the fall in fatality rates (Figure 42) from that for someone focussing on the increasing number of elderly casualties in country areas (Figure 29). Our reaction to the data is that some of the concern is overstated because it results from attention to numbers rather than rates, to particular subsets of accidents rather than others, or to random short-term fluctuations, and that some of the concern is justified.

Acknowledgements

This study was funded by South Australia's 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 of Transport and Urban Planning.

We thank Dr Ron Somers of the Injury Surveillance and Control Unit, SA Department of Health, for access to hospital in-patient statistics. Of course, we are also grateful for the care taken by the many people involved in the collection and processing of road crash data.

The views expressed in this report are those of the authors and do not necessarily represent those of the University of Adelaide or the sponsoring organisations.

References

Anderson, P. R., Adena, M. A., and Montesin, H. J. (1993a). Trends in road crash fatality rates: Australia 1970-1990. Report CR 113, Federal Office of Road Safety, Canberra.

Anderson, P. R., Adena, M. A., and Montesin, H. J. (1993b). Trends in road crash fatality rates: International comparisons with Australia 1970-1990. Report CR 114, Federal Office of Road Safety, Canberra.

ATSB (2003). Road crash data and rates, Australian states and territories 1925 to 2002. Canberra: Australian Transport Safety Bureau.

FORS (1993). Road crashes resulting in hospitalisation, Australia, 1990. Canberra: Federal Office of Road Safety.

FORS (1995). Road crashes resulting in hospitalisation, Australia, 1991. Canberra: Federal Office of Road Safety.

Harris, A. H., Cercarelli, L. R., and Hobbs, M. S. T. (1992). Historical trends in road accident types, deaths and casualties in Western Australia. Australian Journal of Public Health, 16, 117-128.

Harry, A. (1997). Economic indicators in road crash modelling. Report for the South Australian Office of Road Safety.

Hutchinson, T. P. (1987). Road Accident Statistics. Adelaide: Rumsby Scientific Publishing.

Hutchinson, T. P., and Harris, R. A. (1978). Recent trends in traffic injury. Injury, 10, 133-137.

Hutchinson, T. P., and Mayne, A. J. (1977). The year-to-year variability in the numbers of road accidents. Traffic Engineering and Control, 18, 432-433

Li, L., and Routley, V. (1998). Trends in road traffic fatality and injury in Victoria. Hazard, No. 36.

McColl, R. (2003). Differences between CTP insurance statistics and crash statistics. In Proceedings of the 2003 Road Safety Research, Policing and Education Conference, Volume 2, pp. 444-450.

North, B., Oatey, P., Jones, N., Simpson, D., and McLean, A. J. (1993). Head injuries from road accidents --- A diminishing problem? Medical Journal of Australia, 158, 433.

O'Connor, P. (2000). Trends in road fatalities versus serious casualties in South Australia, 1986-1998. Report from Flinders University.

O'Connor, P. (2002). Possible artefacts in SA road crash severity trends. Report from Flinders University.

Transport SA (2003). Road Crashes in South Australia 2002. Walkerville, South Australia: Transport SA. (Also at http://www.transport.sa.gov.au/safety/road/road_use/roadcrash.asp)