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Travelling Speed and the Risk of Crash Involvement on Rural Roads

Kloeden CN, Ponte G and McLean AJ

Road Accident Research Unit
Adelaide University

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Authors

Kloeden CN, Ponte G and McLean AJ

Performing Organisations

Road Accident Research Unit
Adelaide University
SOUTH AUSTRALIA 5005

Sponsored by / Available from

Australian Transport Safety Bureau
PO Box 967
CIVIC SQUARE ACT 2608 Project Officer: John Goldsworthy

Abstract

The relationship between free travelling speed and the risk of involvement in a casualty crash in 80 km/h or greater speed limit zones in rural South Australia was quantified using a case control study design. The crashes involving the 83 case passenger vehicles were investigated at the scene by the Road Accident Research Unit and reconstructed using the latest computer aided crash reconstruction techniques. The 830 control passenger vehicles were matched to the cases by location, direction of travel, time of day, and day of week and their speeds were measured with a laser speed gun. It was found that the risk of involvement in a casualty crash increased more than exponentially with increasing free travelling speed above the mean traffic speed and that travelling speeds below the mean traffic speed were associated with a lower risk of being involved in a casualty crash. The effect of hypothetical speed reductions on all of the 167 crashes investigated indicated large potential safety benefits from even small reductions in rural travelling speeds.

Keywords

Speed, Risk, Speed Limit, Casualty, Crash, Reconstruction, Rural

<u>NOTES</u>:

(1) This report is disseminated in the interests of information exchange.
(2) The views expressed are those of the author(s) and do not necessarily represent those of the Commonwealth.

EXECUTIVE SUMMARY

The main aim of this project was to quantify the relationship between free travelling speed and the relative risk of involvement in a casualty crash, for sober drivers of passenger vehicles in rural out of town 80 km/h and above speed limit zones in South Australia.

The secondary aim of the project was to examine the effect of various hypothetical speed reductions on rural casualty crash frequency.

Using a case control study design and logistic regression modelling, the speeds of passenger vehicles involved in casualty crashes (the cases) were compared with the speeds of passenger vehicles not involved in crashes but travelling in the same direction, at the same location, time of day, day of week, and time of year (the controls). The conditions imposed on the selection of case vehicles were designed to ensure that the study would yield valid estimates of the relative risk of a passenger vehicle travelling at a free speed on a rural road becoming involved in a casualty crash compared to the risk for a passenger vehicle travelling at the average speed of the control vehicles.

The pre-crash travelling speeds of the case vehicles were determined using computer-aided accident reconstruction techniques. This was made possible by the detailed investigation of each crash at the scene which provided the physical evidence needed for input to the computer reconstruction program (M-SMAC).

Additional information about the effects of travelling speed on casualty crash involvement was obtained by calculating the expected reduction in rural crashes due to various hypothetical reductions in vehicle travelling speeds in rural areas.

We found that the risk of a free travelling speed passenger vehicle being involved in a casualty crash, relative to the risk for a passenger vehicle travelling at an average speed, increased at greater than an exponential rate. No evidence was found of a U-shaped risk curve whereby slower vehicles were also at greater risk. We are aware of a number of matters which could have affected the validity of the risk estimates and they are discussed in the report. However, we are not aware of any consistent bias which would be likely to invalidate the general relationship between free travelling speed and the risk of involvement in a casualty crash that we present in this report.

Our results show that the risk of involvement in a casualty crash is more than twice as great when travelling 10 km/h above the average speed of non-crash involved vehicles and nearly six times as great when travelling 20 km/h above that average speed. The mechanisms explored for this increase in risk (where higher speeds are associated with longer stopping distances, increased crash energy and more likely loss of control) also suggest that a reduction in the absolute speed of traffic is much more important in reducing crash frequency than a reduction in traffic speed differences.

In order to explore the possible effect of changing vehicle travelling speeds on rural casualty crash frequency the risk curve was applied to the crashes investigated in this study under a number of hypothetical scenarios. It was found that a large proportion of the casualty crashes attended in this study would have been avoided had the free travelling speed vehicles been travelling at a slower speed. It was shown that even small reductions in travelling speeds have the potential to greatly reduce crash and injury frequency. For example, it is estimated that even a 5 km/h reduction in the speed of all the rural free travelling speed vehicles in this study would have led to a 31 per cent reduction in casualty crashes. This percentage applies to the total sample of casualty crashes investigated, including those for which the hypothetical speed reduction was deemed to be irrelevant (for example, crashes where no vehicle had a free travelling speed). It was also estimated that 24 per cent of all the casualty crashes investigated would have been avoided if none of the vehicles had been travelling above the speed limit and that lowering the maximum speed limit on undivided roads to 80 km/h could be expected to lower casualty crash frequency by 32 per cent.

Conclusions and Recommendations

In rural out of town areas, the risk of involvement in a casualty crash increases greater than exponentially with increasing free travel speed. Even travelling just 10 km/h faster than the average speed of other traffic was found to double the risk of crash involvement.

It was also found that small reductions in travelling speed in rural areas have the potential to greatly reduce casualty crashes in those areas; that illegal speeding is responsible for a significant proportion of rural crashes; and that reducing the maximum speed limit on undivided roads to 80 km/h could be expected to have a marked effect on casualty crash frequency.

We therefore recommend that:

1. The level of enforcement of speed limits in rural areas be increased.

2. The tolerance allowed in the enforcement of rural speed limits be reduced or eliminated.

3. All currently zoned 110 km/h undivided roads be rezoned to no more than 100 km/h.

4. Speed limits be reduced where current limits are considerably greater than average travelling speeds and where there are frequently occurring Advisory Speed signs.

5. After a period with stricter enforcement of rural area speed limits, consideration be given to changing the maximum speed limit to 80 km/h on all two lane rural roads, as is the practice on two lane rural roads in many States in the USA.

6. The level of public awareness of the risk of involvement in a casualty crash associated with speeding be increased with the aim of developing a culture of compliance with speed limits, and support for strict limits, similar to that which has developed in relation to compliance with blood alcohol limits during recent decades.

7. To assist with the preceding recommendation, we also recommend that the results of this study be widely publicised.

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1. INTRODUCTION

Excessive speed is reported to be an important contributory factor in many crashes. Analyses of a number of large data bases in the United States indicated that speeding or excessive speed contributed to around 12 per cent of all crashes reported to the police and to about one third of fatal crashes (Bowie and Walz, 1991). In Australia, it has been reported that excessive speed is an important factor in approximately 20 per cent of fatal crashes (Haworth and Rechnitzer, 1993) and speed is a probable or possible cause in 25 per cent of rural crashes (Armour and Cinquegrana, 1990). It has been argued that such figures are likely to under-estimate the role of speed in crashes because subtle effects, such as the amplification of other dangers in the traffic situation by relatively small increases in speed, are likely to be overlooked (Plowden and Hillman, 1984).

A large body of evidence indicates that there is a positive association between speed and the risk of crash involvement. This evidence includes the findings from case control studies and from studies of fatality and casualty rates before and after changes to speed limits, and evidence from comparisons of fatality rates for countries with different maximum speed limits. Three case control studies conducted in the United States more than 20 years ago attempted to quantify this association, but the validity of the results and their interpretation have been questioned.

More recently, a study carried out in Metropolitan Adelaide established the relationship between travelling speed and the risk of crash involvement using a case control study design in an urban setting (Kloeden, McLean, Moore and Ponte, 1997). This study found an exponential increase in crash risk with increasing travel speed above the urban area speed limit of 60 km/h and that there appeared to be as high a crash risk involved in travelling more than 15 km/h above the 60 km/h speed limit as there was in driving with a blood alcohol concentration above 0.15.

The study reported here applied the general research methods developed in the Adelaide study to an investigation of the association between speed and the risk of involvement in a casualty crash in rural areas.

1.1 Aims of this Project

The main aim of this project was to quantify the relationship between free travelling speed and the relative risk of involvement in a casualty crash, for sober drivers of passenger vehicles in rural out of town 80 km/h and above speed limit zones in South Australia. Using a case control study design and logistic regression modelling, the speeds of passenger vehicles involved in casualty crashes were compared with the speeds of passenger vehicles not involved in crashes but travelling in the same direction, at the same location, time of day, day of week, and time of year.

The secondary aim of the project was to examine the effect of hypothetical speed reductions on this set of crashes to allow some insight to be gained into the possible effects of changing the speed behaviour of rural drivers.

1.2 Literature Reviews on Speed and Crash Risk

For a detailed discussion of the literature on speed and crash risk, see Kloeden, McLean, Moore and Ponte (1997). That report examined the available literature on case control type studies, driver's characteristic speed and crash history studies, and correlation studies. Correlational studies have demonstrated a positive association between speed and crash involvement and crash history studies have reported a relationship that is not U-shaped. Previous case control studies that have found a U-shaped relationship between speed and crash risk were critically assessed. A modified version of this criticism is presented below as it is directly relevant to the current study.

Another more recent publication that examines the relationship between speed and crashes as well as looking at more general issues surrounding the management of speed was published by the Transportation Research Board (1998).

1.3 Previous Rural Speed Case Control Studies

Three studies undertaken in the United States more than 30 years ago attempted to quantify the relationship between speed and crash involvement by ascertaining pre-crash speeds for individual vehicles in a rural setting (Solomon, 1964; Cirillo, 1968; Research Triangle Institute, 1970). In each study the essence of the method was to estimate pre-crash travelling speeds for vehicles involved in crashes on designated stretches of road, and to compare these speeds with speed measurements for traffic not involved in crashes. The studies were conducted on rural roads, and all reported that the relationship was U-shaped, with crash risk being elevated at both relatively low and relatively high speeds. However, critical appraisal of these studies highlights the possibility that aspects of the way the studies were carried out inadvertently contributed to the apparent increase in risk at relatively low travelling speeds. Thus it is arguable that these studies did not reliably quantify the relationship between speed and crash involvement at the lower end of the speed distribution. By contrast, the estimates of crash risk at the upper end of the speed distribution appear to be free of severe bias and may be taken as indicative, at least for that place and time.

The first and best known attempt to quantify the relationship between speed and crash involvement was that of Solomon (1964), undertaken in the United States in the late 1950s. The aim of Solomon's study was to relate crash involvement to various driver and vehicle factors, including speed. To this end, information from the accident records of nearly 10,000 drivers was compared with speed measurements and interview data from 290,000 drivers not involved in crashes.

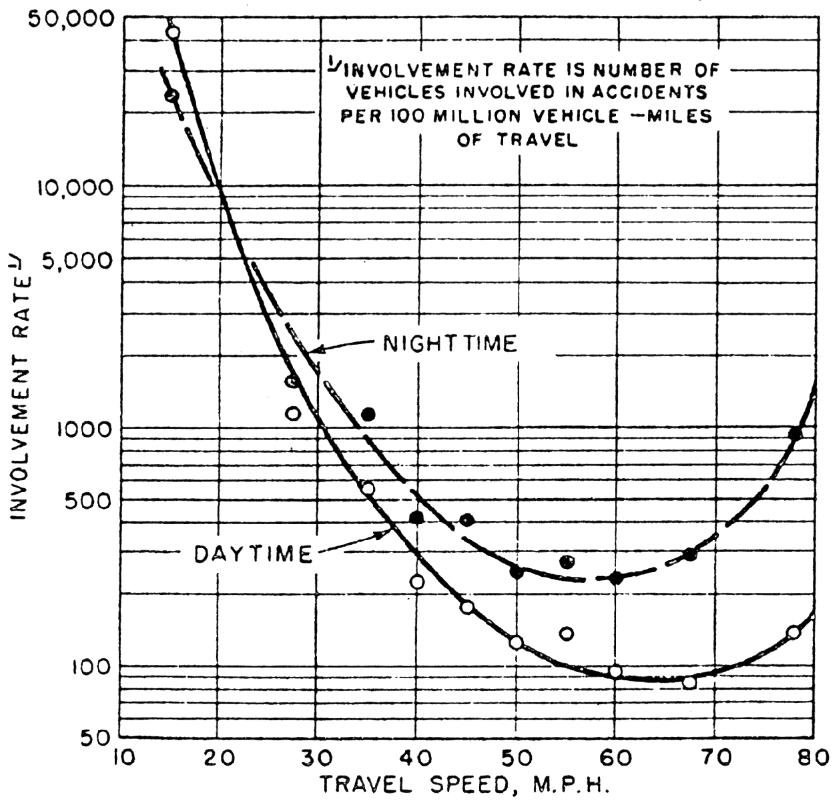
Six hundred miles of main rural highway were included in the study, 35 sections in 11 states. The sections were reported to have been representative of main rural highways in the United States: three quarters were two-lane highways, with the remainder being four-lane divided highways; the average section length was 17 miles, although one section was 91 miles long; a daytime speed limit of 55 to 70 mph applied to 28 sections, 45 mph to two sections, and subjective limits (relying on drivers' judgements) to the remainder; on average, there were two entrances to businesses and four intersections per three mile distance. For each section, speed measurements were made using a concealed device at one location, chosen on the grounds that the speeds there were typical of the average for the entire section. Selected drivers were stopped and interviewed after their speeds were registered.

Accident data were obtained from the records of all reported crashes that had occurred on the 35 highway sections during a period of three to four years prior to June 30, 1958. For comparison purposes the 'travel speed' of crash-involved vehicles was required, this being the speed at which the vehicle was moving before the driver became aware of the impending collision. In the accident reports this speed was estimated by drivers, police, or witnesses; about 20 per cent of accident reports did not contain an estimate.

While the information collected enabled the speed distributions of accident-involved and non-involved drivers to be directly compared, the results were also presented in a manner that took into account the amount of travel at a particular speed, that is, in terms of involvements per hundred million vehicle-miles (100 mvm). To achieve these involvement rates, the vehicle-miles for each section were calculated as the product of the section length and the number of vehicles using the section over the period for which accident data were obtained, extrapolated from traffic volume counts. The vehicle-miles were then apportioned to speed categories according to the distribution of speeds obtained for the section; the figures for the different sections were combined to give total vehicle-miles for each speed band. Finally, the number of involvements with reported travel speed in a particular category was divided by the total vehicle-miles for that category.

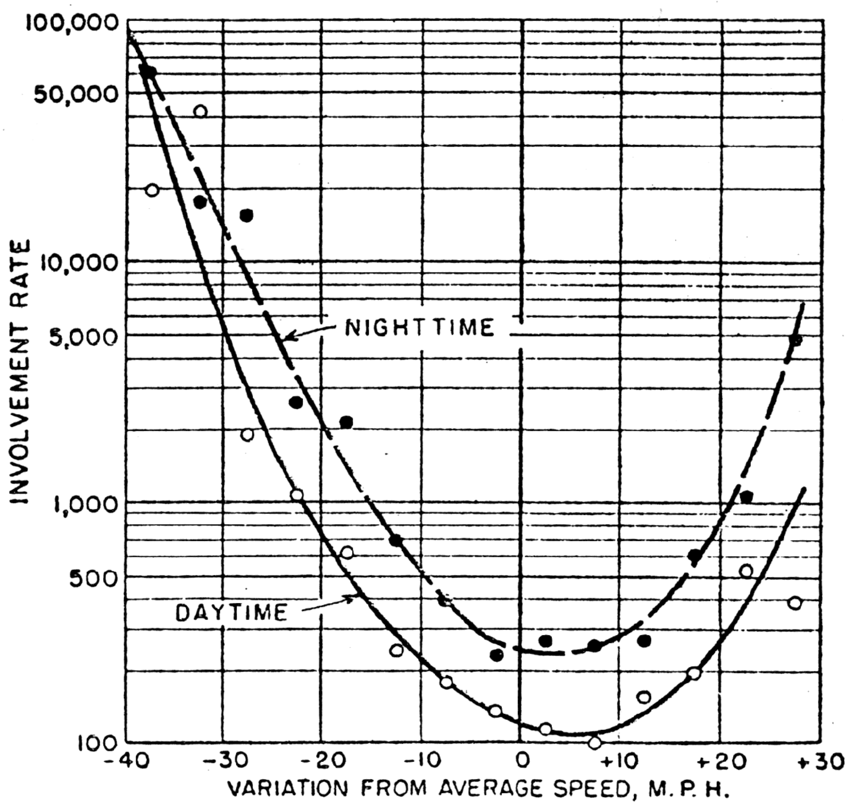
Solomon found that the daytime involvement rates took the form of a U-shaped curve, being greatest for vehicles with speeds of 22 mph or less (43,238 per 100 mvm), decreasing to a low at about 65 mph (84 per 100 mvm), then increasing somewhat for speeds above this (reaching 139 per 100 mvm for speeds of at least 73 mph); the night-time rates took the same form but, except for that of the lowest speed category, were higher, especially for speeds in excess of 60 mph. These results are reproduced in Figure 1.1.

Figure 1.1
Results of Solomon (1964, p 10)
Accident Involvement Rate by Travel Speed, Day and Night



Solomon also expressed the involvement rates as a function of deviation from mean speed, to overcome irregularities due to the highway sections having a range of speed limits and mean speeds. Under this configuration the involvement rates were again U-shaped, being maximum for vehicles with speeds of more than 35 mph below the average, minimum for speeds of 5 to 10 mph above the average, and somewhat elevated for further deviations above the average. These results are depicted in Figure 1.2.

Figure 1.2
Results of Solomon (1964, p 16)
Accident Involvement Rate by Variation from Average Speed on Section, Day and Night



In addition, severity was taken into account through the presentation of separate involvement rates for crashes with different consequences. The involvement rates for crashes which resulted in injury followed a U-shaped curve that was more symmetric than the curve for all crashes, with a sharper increase evident in the rates at high speeds. This difference was even more prominent for the curve of involvement rates for crashes which resulted in a fatality. Table 1.1 illustrates the differences between the overall and the consequence-specific involvement rates, for day and night combined, and was compiled from data contained in Solomon's report.

Table 1.1
Rates for All Accident Involvements and for
Consequence-Specific Involvements (from Solomon, 1964)

Speed Category (mph)	Involvements per 100 mvm	Persons Injured per 100 mvm	Persons Killed per 100 mvm
≤ 22	38,873	9,343	446
23 - 32	1,274	356	12
33 - 42	362	110	5
43 - 52	188	62	5
53 - 62	143	70	4
63 - 72	121	93	2
≥ 73	289	313	118

From a public health perspective, the consequence-specific rates are more important than the overall involvement rates which give the probability of being involved in a crash regardless of the outcome. The overall involvement rates are therefore misleading with regard to the safety of particular speeds, since outcome worsens with increasing speed.

Despite the apparent thoroughness of these results, there are several features of the method that are highly likely to have introduced substantial bias, particularly in relation to the estimates of crash risk at the lower end of the speed distribution. Both the numerator (number of crashes in a particular speed band) and the denominator (number of vehicle-miles travelled in that same speed band) may have been quite inaccurate for relatively low speeds.

Considering the number of low-speed crashes, this could be biased through making use of pre-crash speed estimates reported by the drivers involved. Solomon was aware of the obvious possibility that drivers might tend to under-estimate their speeds, but maintained it was inconsequential. However, in a discussion of Solomon's work, White and Nelson (1970) insisted that under-estimation of pre-crash speeds by this means was important, and through a type of sensitivity analysis showed that such a bias could contribute to a U-shaped pattern which did not, in fact, represent the true relationship.

In addition, it is possible that crashes at entrances to businesses or intersections accounted for many of the slow moving vehicles. Solomon acknowledged this possibility also, even suggesting that as many as half of the involvements in the 10 to 30 mph category were of this nature, but claimed that excluding such crashes would change the results very little. This claim is somewhat at odds with the explanation offered for the lower involvement rates on four-lane highways compared with two-lane highways, which was in terms of the superior control of access on four-lane highways. It is also clear from Solomon's work that the pattern of involvement rates varied with the type of crash, with rear-end collisions being much more likely to occur at low than at high speeds. Thus it is difficult to accept that removing low-speed crashes associated with particular manoeuvres (rather than low free speeds) would hardly affect the results.

Turning to the denominator, the potential for bias there exacerbates the likelihood that an artifactual U-shaped curve would emerge from the data. Recall that for each section of highway, crashes along the whole length were included in the study, but comparison speeds were measured at only one location at selected times. Although this location was chosen to be in some sense typical of the section, speeds there may not have represented the speed of traffic at crash locations, particularly when driveways or entrances to businesses were proximal to the latter. It is also difficult to comprehend how speeds measured at one location can be considered to be adequately representative of speeds on road sections up to 91 miles in length. Hence it is conceivable that the comparison speed distributions, which formed the basis for the denominator of the crash rates, systematically omitted low speeds that would have been found at crash locations.

A few years later Cirillo (1968) published results of a study similar to Solomon's, but undertaken on interstate highways rather than rural highways. Briefly, twenty state highway departments supplied the data which related to rural and urban sections of interstate highways, with a number of criteria applied to eliminate intersections and to make the sections somewhat homogeneous. Information was obtained on the proportion of traffic in different speed categories and the speeds of vehicles involved in crashes. Only crashes which occurred between 9 am and 4 pm and which were either rear-end, same-direction side-swipe or angle collisions were included. The time restriction was necessary for compatibility with the speed data collected for non-involved vehicles, while the type of collision was restricted as the focus was on the way differences in speeds of vehicles in the same traffic stream contributed to crashes.

Cirillo's results were expressed in terms of deviation from mean speed and were similar to those of Solomon: the accident involvement rates followed a U-shaped curve, being highest for vehicles travelling about 32 mph below the mean speed, falling to a minimum for vehicles travelling around 12 mph above the mean speed, then rising moderately with further deviations from the mean. In addition, the relationship between involvement rates and proximity to an interchange (a connection between major roads) was examined. In urban areas, the involvement rates were highest for sections closest to interchanges and decreased as distance from the interchange increased. There was no obvious pattern for sections in rural areas. In general, the rates at urban interchanges were higher than those for rural interchanges.

These results suggested a role for traffic volume as well as speed differences in the occurrence of crashes.

It follows from the similarity in procedures that Cirillo's study suffers from much the same potential for bias as Solomon's work. In addition, Cirillo's results only relate to specific crash types. The Insurance Institute for Highway Safety (1991) pointed out that single vehicle crashes account for more than half of the fatal crashes on interstate highways and such crashes are likely to be associated with high speeds, so the omission of this type of crash means that Cirillo's study almost certainly under-estimated the involvement rates for high speeds. Furthermore, again according to the Insurance Institute for Highway Safety, many of the very slow speeds were probably related to disabled vehicles leaving the road or at the side of the road, rather than to elected travelling speeds of vehicles in the traffic stream.

A third study which aimed to quantify the relationship between speed and the occurrence of a crash was reported by the Research Triangle Institute (1970). It was undertaken a decade after Solomon's study and, while the essential idea was the same, some aspects of the method were different. The study covered all state highways and county roads with a speed limit or a mean speed of at least 40 mph in Monroe County, Indiana, in all about 70 miles of road. A total of 294 crashes were included in the study.

Efforts were made to obtain pre-crash speeds that were more reliable than those abstracted from accident reports, including the use of accident investigation and of a computer-sensor system. For the first eight months of the study an accident investigation team determined the pre-crash speeds on the basis of physical evidence at the crash site and driver and witness reports. In the meantime, a computer-sensor system (basically a series of magnetic loop pairs connected to an on-line computer enabling collection of speeds and traffic volumes) was developed. The sensors were embedded at 16 points along the main highway, Indiana Highway 37. Using this system it was possible to identify accident-involved vehicles or the platoon in which they had been travelling and thereby obtain pre-crash speeds, so accident investigation was replaced by the computer-sensor system for the last few months of the study.

Further information on the operation and output of the computer-sensor system was provided by West and Dunn (1971). In order to test the reliability of the system, measures of pre-crash speed for a group of 36 crashes were obtained using both available methods. It was found that in a quarter of the cases the speed of the accident-involved vehicle or the platoon in which it had been travelling could be identified confidently from the computer output (a result which seemed to be regarded as an achievement rather than as a cause for misgivings about the quality of the data). Some information was retrievable for the remaining crashes, but it was not made clear how these less certain estimates were gained or treated.

The findings of the Research Triangle Institute for state highways were only presented in terms of accident involvement rates for categories of deviation from the mean speed, calculated in a similar manner to those of Solomon. However, in recognition of the distorting influence of vehicles executing turning manoeuvres, crashes in which such a manoeuvre occurred (44% of the total cases) were excluded from the analysis. Based on data for 154 vehicles, the pattern of involvement rates was a U-shaped curve, as shown in Table 1.2, but the elevated rates at low speeds were not nearly as pronounced as those of Solomon.

Table 1.2
Relationship Between Accident Involvement Rate and Speed Deviation (Research Triangle Institute, 1970, p. 17)

Deviation from Mean Speed (mph)	Involvements per mvm
< -15.5	9.8
-15.5 to -5.5	0.8
-5.5 to 5.5	0.8
5.5 to 15.5	1.3
> 15.5	9.8

For a subset of the Research Triangle Institute data, West and Dunn elaborated on the exclusion of crashes which involved a turning vehicle: the involvement rate for vehicles with speeds of more than 15.5 mph below the mean speed was reduced by a factor of seven when such crashes were excluded, while the other rates changed only a little. This result provides an explanation for the high crash rates at low speeds in Solomon’s study.

1.4 A Previous Urban Speed Case Control Study

The study by Kloeden, McLean, Moore and Ponte (1997) attempted to address the limitations in the previous case control studies and obtain a relationship between travelling speed and crash risk in an urban area. The key points of the study were:

- in-depth at scene investigation of crashes
- detailed crash reconstruction of relevant cases
- time, place, and direction of travel matched control vehicles
- each case and control vehicle had a free travelling speed
- alcohol eliminated as a confounding factor

This study found that the relationship between travelling speed and crash risk was not U–shaped. In a 60 km/h speed limit area, the risk of involvement in a casualty crash was found to approximately double with each 5 km/h increase in travelling speed above 60 km/h. Below 60 km/h, no statistically significant difference in risk was found compared to the risk at 60 km/h.

The study of speed and crash risk in rural areas reported here is based on a similar method to that developed for the urban area study.

2. METHOD

The current study was designed to quantify the relationship between travelling speed and the risk of involvement in a casualty crash in a rural area and to examine the likely effects of hypothetical changes in vehicle travelling speeds on casualty crash frequency. The methods and criteria used are presented in the following Sections.

2.1 Source of Data

The cases were drawn from an in-depth at-scene investigation of a sample of rural crashes that was carried out for Transport SA. The crashes occurred from 13 March 1998 to 29 March 2000 within a 100 km radius of Adelaide.

2.2 Case Vehicle Selection Criteria

The following criteria were used for the selection of case vehicles:

- The crash was not in a metropolitan or rural town area
- The speed limit at the location of the crash was 80 km/h or greater
- At least one person from the crash scene was treated at, or admitted to, hospital or fatally injured
- The vehicle was a passenger vehicle (car, station wagon, panel van, utility, four wheel drive, passenger van)
- The vehicle was travelling at a free speed before the crash
- The vehicle was not executing an illegal manoeuvre prior to the start of the crash sequence
- The driver was sober
- The driver didn’t crash because of a medical condition or falling asleep
- The driver didn’t crash because of a suicide attempt
- The vehicle travelling speed before the crash could be reconstructed
- The travelling speed was measured for a sufficient number of comparable control (non-crash-involved) vehicles at the crash site

Cases were restricted to crashes occurring outside metropolitan and rural town areas in 80 km/h or greater speed zones in order to be representative of crashes on rural roads and highways.

A resultant injury at least severe enough to require treatment at hospital was used as the crash severity criterion.

Requiring the case vehicle to be a passenger vehicle was specified in an attempt to get a relatively homogeneous sample of cases. It would be expected that other vehicle types, such as heavy trucks, would have different travelling speeds from those of passenger vehicles on some rural roads.

The case vehicles all had a free travelling speed prior to the crash. A free travelling speed was defined as the speed of a vehicle moving along a road, or with right of way through an intersection, not closely following another vehicle, and not slowing to leave a road, or accelerating on entering one. This criterion operationally defined travelling speed as it is popularly understood and aimed to ensure that the association between travelling speed and crash involvement was not confused by the inclusion of vehicles executing (necessarily slow) manoeuvres or disobeying right-of-way rules.

Vehicles executing illegal manoeuvres prior to the crash sequence were excluded as cases since they would have had other high risk factors involved. For example, going through a Stop sign without stopping increases the risk of a crash regardless of the travelling speed of the vehicle.

In order to assess the relationship between travelling speed and the risk of crash involvement without possible confounding by other high risk factors, a case was included only if the driver's BAC was measured and found to be zero, and the crash didn't result from a driver being affected by a medical condition, falling asleep or attempting suicide.

There also had to be sufficient information available for a computer-aided or other reconstruction of the crash to be conducted to give a reliable estimate of the travelling speed of the vehicle before the crash.

The final requirement was that it had to be possible to collect 10 control speeds for each crash location. In some instances the traffic volume was too low to collect enough control speeds and in some others the road conditions or speed limits on the roads changed soon after the crash meaning that comparable vehicle speeds could not be collected.

In summary, the conditions imposed on the selection of crashes, case vehicles, and controls were designed to ensure that the study would yield valid estimates of the relative risk of a passenger vehicle travelling at a free speed in a rural area becoming involved in a casualty crash.

2.3 Case Vehicle Investigation Procedure

The following procedure was used in the investigation of crashes:

- Notification of crash by ambulance paging service or radio
- Attendance at scene by RARU personnel
- Photographs and measurements of scene
- Photographs and measurements of vehicles
- Interviews with police, participants and witnesses at scene
- Follow up interviews with participants and witnesses
- Review of information collected by the police
- Review of data on drivers' blood alcohol levels
- Review of Coroner's reports in fatal cases
- Review of case material by expert panel
- Final decision on case suitability
- Computer-aided reconstruction of the crash
- Estimation of travelling speed before the crash

The primary method of being advised of the occurrence of a vehicle accident was an arrangement whereby the South Australian Ambulance Service notified the Road Accident Research Unit (RARU) of calls for an ambulance to attend a crash in rural areas by means of a paging service. Members of RARU also monitored the ambulance radio frequency.

Upon the receipt of notification, RARU personnel proceeded directly to the crash scene. On arrival, one of the crash investigation team photographed the scene and the vehicles involved while the other member interviewed police, participants and witnesses. Relevant measurements of the vehicles and the scene were also made. In some cases, vehicles were followed up at crash repairers for further photographs and measurements.

Where possible, detailed follow up interviews were undertaken with all crash participants and, when permission was granted, medical notes for injured occupants were examined.

The police accident report on the crash was reviewed to obtain any further crash details. For drivers who were transported to hospital, the results from the compulsory blood alcohol test taken in hospital were also reviewed. In fatal cases, a copy of the Coroner's report on the crash was obtained.

All information about the crash was then reviewed by an expert panel to determine the suitability of the case. If the crash was found to satisfy the criteria for inclusion in this study it was then reconstructed using computer-aided reconstruction and other techniques in an attempt to obtain a valid estimate of the travelling speeds of the vehicles.

Investigators were on call to attend crashes from 9:00 am to 5:00 pm, Monday to Friday, and also on Thursday and Friday nights and during the day on Saturday and Sunday. Some fatal crashes that occurred outside these times were investigated on a follow-up basis. This was made possible when SA Police Major Crash Investigation personnel had attended the scene and marked the point of impact and rest positions of the vehicles.

2.4 Determining Speeds of Case Vehicles

The pre-crash travelling speeds of the case vehicles were determined using accident reconstruction techniques. This was made possible by the detailed investigations of the crashes at scene. Features of the crash such as tyre marks, impact points, final positions of vehicles, damage to vehicles, and participant and witness statements were all used in the reconstruction process. The crash scene was surveyed using a Geodometer and a computer-generated scale plan was prepared.

Considerable use was made of the SMAC (Simulation Model of Automobile Collisions) computer program that was developed by Ray McHenry at the (then) Cornell Aeronautical Laboratory of Cornell University about 30 years ago.

SMAC, despite the inclusion of the word "simulation" in the name, is a true reconstruction program in which each step has been developed on the basis of physical testing and studies of vehicle dynamics. In application, it is an iterative program in which a collision between two cars is modelled by starting with the alignment of the cars on impact, which can be determined from the damage to the cars, and estimating impact velocities. The predicted post-impact motions of the vehicles are then compared with the actual motions, deduced from skid marks and the rest positions. If necessary, adjustments are made to the modelled impact geometry and impact velocities until a satisfactory match is obtained.

Having been developed for the United States Bureau of Public Roads, the SMAC program was available in the public domain and now is used in a number of commercially available packages, such as ED-SMAC. A simplified version of SMAC, CRASH (Cornell Reconstruction of Accident Speeds on the Highway) was also developed in the 1970s. It enables a less accurate estimate of impact speed to be made from the nature and extent of the collision damage to a car. McHenry, with his son Brian McHenry, has continued to develop both SMAC and CRASH and so the Road Accident Research Unit (RARU) entered into an arrangement whereby the latest versions of both programs were made available and Brian McHenry visited Adelaide to instruct RARU staff in their use. Subsequently, during the study, in some cases the crash data and the RARU reconstruction were sent to Brian McHenry in North Carolina for assessment and, if necessary, a re-run of what they now refer to as the M-SMAC program.

Other methods were also used to establish both impact and travelling speeds. They are all described in some detail in Volume 2 of the study by Kloeden, McLean, Moore and Ponte, (1997).

2.5 Control Vehicle Speed Collection

The following criteria were used in the selection of control vehicles:

- Same location, weather conditions, day of week, time of day and natural lighting conditions as the crash
- Same direction of travel as the case vehicle
- Vehicle was a passenger vehicle
- Vehicle had a free travelling speed (as defined for case vehicles)

Among the vehicles meeting the control selection criteria, a sample had their speed measured by a member of the Unit using a laser speed meter. This meter can measure the speed of a specified car to within 1 km/h from distances up to 1 km away. The minimum distance from the meter to the car while measuring control speeds was 200 metres. The laser speed meter that was used is similar in appearance to a video camera. Even so, every effort was made to avoid alerting the drivers to the presence of speed measuring equipment.

Testing continued until 10 controls were collected for each case vehicle or it became obvious that 10 controls would not be collected in a reasonable amount of time. Where 10 controls could not be collected the case was abandoned. Where the 10 controls could be collected they formed the control group for that case.

2.6 Determination of Relative Risk Curve

While the speeds of the case and control vehicles at the sites of rural crashes could be calculated, they could not be used directly to calculate a crash risk curve. This is because they amalgamate sections of road with very different travelling speed distributions. For example, the speeds of vehicles around a curve with an Advisory Speed sign of 45 km/h will be much lower than for vehicles travelling on a straight 110 km/h speed limit section of road. These two situations cannot be directly compared in terms of absolute speed and crash risk.

After exploring various possible methods of normalising the data, it was decided to normalise both the case and control speeds at a given crash site by expressing them as a speed difference from the average of the control speeds at that site.

Modified logistic regression modelling was then used to establish the shape of the casualty crash relative risk curve.

2.7 Hypothetical Crash Outcome Method

Additional information about the relationship between travelling speed and crash involvement was obtained by calculating what the likely change in the expected number of rural casualty crashes would have been if the vehicles in this study had been travelling at different speeds.

The following hypothetical Scenarios were examined:

1. Uniform 5 km/h speed reduction applied to all free travelling speed vehicles
2. Uniform 10 km/h speed reduction applied to all free travelling speed vehicles
3. Uniform 20 km/h speed reduction applied to all free travelling speed vehicles
4. No free travelling speed vehicles travelling above the average speed of the control vehicles
5. Total compliance with speed limits by all free travelling speed vehicles
6. Total compliance with Advisory Speed signs by all free travelling speed vehicles
7. Maximum speed limit reduced to 80 km/h on all undivided roads with similar compliance to that at present

Under Scenario 1, all free travelling speed vehicles were assumed to have a travelling speed 5 km/h less than their calculated travelling speed.

Under Scenario 2, all free travelling speed vehicles were assumed to have a travelling speed 10 km/h less than their calculated travelling speed.

Under Scenario 3, all free travelling speed vehicles were assumed to have a travelling speed 20 km/h less than their calculated travelling speed.

Under Scenario 4, all free travelling speed vehicles with a calculated travelling speed above the average speed of the control vehicles at a given crash site were assumed to be travelling at the average speed of the control vehicles at that site.

Under Scenario 5, all free travelling speed vehicles with a calculated travelling speed above the speed limit were assumed to be travelling at the speed limit.

Under Scenario 6, all free travelling speed vehicles subject to an Advisory Speed sign with a calculated travelling speed above the Advisory Speed were assumed to be travelling at the Advisory Speed.

Under Scenario 7, all free travelling speed vehicles that were travelling in 80 km/h speed zones or on divided roads did not have their speeds changed; all free travelling speed vehicles on undivided roads where the speed limit was 90 km/h or greater which were travelling at an estimated speed between 80 km/h and the speed limit had their speeds set to 80 km/h; all free travelling speed vehicles on undivided roads where the speed limit was 90 km/h or greater which were travelling at an estimated speed above the speed limit had their speeds reduced by the difference between the speed limit and 80 km/h (eg a vehicle travelling at 125 km/h in a 100 km/h zone had its hypothetical speed reduced to 105 km/h); the speeds of vehicles travelling below 80 km/h were unchanged. This scenario was intended as a first approximation estimate of the effect of reducing the maximum speed limit on undivided roads to 80 km/h.

Further details of the method used are given in the hypothetical scenarios results Section 3.9.

3. RESULTS

The results of the study are presented below. Summary information is presented on all the relevant crashes investigated and the crash involved vehicles. The selection process of case vehicles for this study is given along with the properties of these vehicles. Case and control speeds at the case crash sites are examined and the speed difference distributions of the cases and controls are given. Relative crash risk estimates are made and finally the effect of hypothetical speed reductions on crash frequency are examined.

3.1 Crashes Investigated

During the two years of crash investigation for this study, a total of 167 crashes met the basic crash criteria whereby the crash occurred on a rural road having a speed limit of 80 km/h or greater and the crash resulted in at least one person being treated at, or admitted to hospital or fatally injured.

Crash severity was defined in terms of the injury outcome, as shown in Table 3.1. By comparison the severity of non-metropolitan crashes in South Australia in 1997 is shown in Table 3.2 (source: Transport Information Management Section, 2000). It can be seen from these two Tables that the crashes investigated here involve more fatalities. The reason for this is that most fatal crashes are investigated at the scene by Police Major Crash. The physical evidence at the scene (skid and gouge marks, and the final position/s of the vehicle/s) is marked and so it is possible to reconstruct the crash events even though our investigators may not have been at the scene before the vehicles were removed. It should also be noted that Tables 3.1 and 3.2 are not strictly comparable since Table 3.2 includes crashes in rural towns and Table 3.1 does not and that the crashes in Table 3.1 were restricted to crashes within 100 km of Adelaide.

Table 3.1
Severity of South Australian Rural Crashes Investigated

Crash Severity	Number	Per cent
Treated at hospital	55	32.9
Admitted to hospital	65	38.9
Fatality	47	28.1
Total	**167**	**100.0**

Table 3.2
Severity of South Australian
Non-Metropolitan Crashes 1997

Crash Severity	Number	Per cent
Treated at hospital	924	61.6
Admitted to hospital	504	33.6
Fatality	72	4.8
Total	**167**	**100.0**

If, as is generally assumed, higher travelling speeds are associated with more serious crashes then the current analysis may introduce a bias towards higher risk estimates for casualty crashes as a whole. Since the existence or size of this effect is unknown it is more precise to say that that our risk estimates are based on a higher than average level of crash severity.

Table 3.3 shows the speed limit at the location of the crashes investigated. South Australia has an open road speed limit of 100 km/h in accordance with the Australian road rules. However, major highways are zoned at 110 km/h in rural areas and are sign posted accordingly.

Table 3.3
Speed Limits at Location of
South Australian Rural Crashes Investigated

Speed Limit	Number	Per cent
80	29	17.4
90	7	4.2
100	86	51.5
110	45	26.9
Total	**167**	**100.0**

Table 3.4 shows the Advisory Speed in effect at the location of the crashes investigated as indicated by Advisory Speed signs. While these signs are not legally binding they do advise the driver of a safe speed to negotiate a particular section of road.

Table 3.4
Advisory Speeds at Location of
South Australian Rural Crashes Investigated

Speed Advisory	Number	Per cent
25	1	0.6
35	2	1.2
45	3	1.8
55	8	4.8
65	5	3.0
75	5	3.0
80	1	0.6
85	5	3.0
none	137	82.0
Total	**167**	**100.0**

Table 3.5 shows the type of road at the location of the crashes investigated. The great majority of the crashes occurred on sealed two lane undivided roads.

Table 3.5
Type of Road at Location of
South Australian Rural Crashes Investigated

Type of Road	Number	Per cent
Sealed two lane undivided	132	79.0
Sealed multi-lane undivided	2	1.2
Sealed multi-lane divided	20	12.0
Unsealed two lane undivided	13	7.8
Total	**167**	**100.0**

3.2 Crash Involved Vehicles

A vehicle was defined as being involved in a casualty crash if an occupant of that vehicle was injured seriously enough to be treated at, or admitted to hospital or fatally injured or if, during the crash sequence, that vehicle came in to physical contact with another vehicle in which an occupant was injured seriously enough to be treated at or admitted to hospital or fatally injured.

Among the 167 casualty crashes investigated there were 259 vehicles that met the above criteria. The types of these vehicles are shown in Table 3.6.

Table 3.6
Types of Vehicles Involved inthe
South Australian Rural Crashes Investigated

Type of Vehicle	Number	Per cent
Car	157	60.6
Four wheel drive	21	8.1
Station wagon	18	6.9
Utility	16	6.2
Semi trailer	14	5.4
Motorcycle	10	3.9
Passenger van	9	3.5
Truck	9	3.5
Panel van	3	1.2
Bicycle	1	0.4
Tractor	1	0.4
Total	**259**	**100.0**

3.3 Case Vehicle Selection

Not all of the vehicles involved in casualty crashes met the selection criteria and some could not be included for lack of required information. Table 3.7 shows the reasons for the exclusion of vehicles resulting in 83 cases being selected from the 259 crash involved vehicles.

Table 3.7
Selection of Case Vehicles
Reasons for Excluding Vehicles
Involved in Casualty Crashes Investigated

Reasons for Exclusion	Number	Number
Total Vehicles in 167 Casualty Crashes		**259**
Not a Passenger Vehicle		-35
Semi trailer	14	
Motorcycle	10	
Truck	9	
Tractor	1	
Bicycle	1	
Not Travelling at a Free Speed		-61
Turning	33	
Overtaking	8	
Following	6	
Slow	4	
Accelerating	4	
U-turn	3	
Stopped	2	
Decelerating	1	
Other Major Risk Factor Present		-37
Positive BAC driver	19	
Fail to give way	9	
Fell asleep	5	
Driver medical condition	3	
Suicide	1	
Eligible Vehicles		**126**
Required Data Missing		-43
Could not reconstruct	32	
Could not get controls	11	
Total Case Vehicles		**83**

Sixty one of the crash involved passenger vehicles were not travelling at a free speed at the time of the crash as defined by the selection criteria in Section 2.2.

The presence of another major risk factor for crashing was used to exclude 37 vehicles.

Among the remaining 126 eligible vehicles, a reliable estimate of travelling speed could not be made for 32 vehicles due to insufficient information being available on the crash. The traffic volume at the location of 11 crashes was too low to allow the collection of sufficient control speeds or the traffic conditions had changed so that controls would not be comparable.

This exclusion process left 83 case vehicles meeting the selection criteria with an estimated travelling speed and corresponding control speed data. These speeds of the case and control vehicles were used to calculate the relative risk of crash involvement.

3.4 Case Vehicle Properties

Table 3.8 shows the types of the case vehicles in this study.

Table 3.8
Types of Case Vehicles

Type of Vehicle	Number	Per cent
Car	57	68.7
Four wheel drive	11	13.3
Station wagon	9	10.8
Passenger van	3	3.6
Utility	2	2.4
Panel van	1	1.2
Total	**83**	**100.0**

Table 3.9 shows the severity of the crashes that the case vehicles were involved in. As noted previously, crash severity was defined in terms of the most severe injury outcome.

Table 3.9
Severity of Crashes that Case Vehicles Were Involved In

Crash Severity	Number	Per cent
Treated at hospital	26	31.3
Admitted to hospital	38	45.8
Fatality	19	22.9
Total	**83**	**100.0**

The speed limits that applied to the case vehicles in this study are shown in Table 3.10 and any Advisory Speeds in Table 3.11. Table 3.12 shows the lower of the Advisory Speed or the speed limit applicable to each of the case vehicles.

Table 3.10
Speed Limit for Case Vehicles

Speed Limit	Number	Per cent
80	17	20.5
90	2	2.4
100	43	51.8
110	21	25.3
Total	**83**	**100.0**

Table 3.11
Advisory Speed for Case Vehicles

Advisory Speed	Number	Per cent
45	2	2.4
55	4	4.8
65	2	2.4
75	4	4.8
85	2	2.4
none	69	83.1
Total	**83**	**100.0**

Table 3.12
Speed Limit or Advisory Speed
(whichever was the lesser)
for Case Vehicles

Speed Limit/Advisory	Number	Per cent
45	2	2.4
55	4	4.8
65	2	2.4
75	4	4.8
80	14	16.9
85	2	2.4
90	2	2.4
100	34	41.0
110	19	22.9
Total	**83**	**100.0**

The type of road that the case vehicles were travelling on is shown in Table 3.13. All case vehicles were travelling on sealed roads as the unsealed road crashes either could not be reconstructed or there was not enough traffic to obtain 10 control vehicles.

Table 3.13
Type of Road for Case Vehicles

Type of Road	Number	Per cent
Sealed two lane undivided	74	89.2
Sealed multi-lane undivided	1	1.2
Sealed multi-lane divided	8	9.6
Total	**83**	**100.0**

3.5 Case and Control Speed Distributions

The travelling speed distributions of the controls and cases are shown in Figures 3.1 and 3.2. While these Figures give an overall impression of the typical speeds of crash-involved and non-crash-involved vehicles at the sites of rural crashes, they cannot be used directly to calculate a crash risk curve. This is because they amalgamate sections of road with very different travelling speed distributions. For example, the speeds of vehicles around a curve with an Advisory Speed sign of 45 km/h will be much lower than for vehicles travelling on a straight 110 km/h speed limit section of road. These two situations cannot be directly compared in terms of absolute speed and crash risk.

Figure 3.1
Control Vehicle Travelling Speeds (n=830)

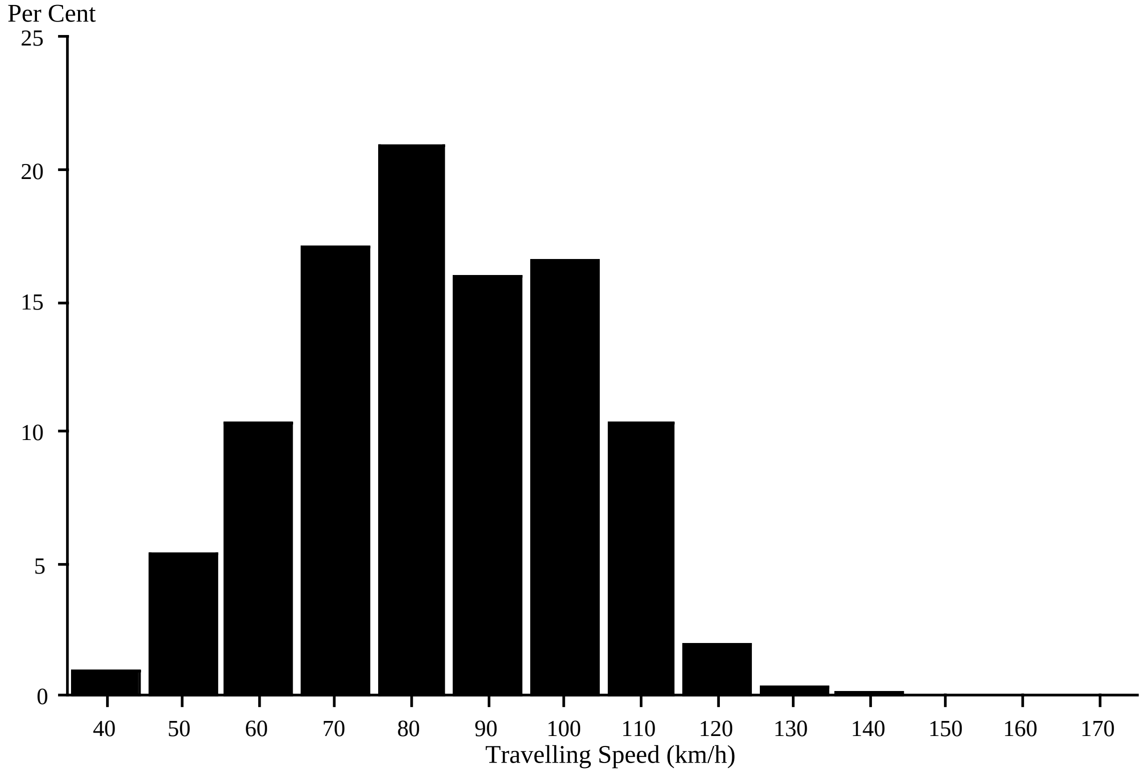
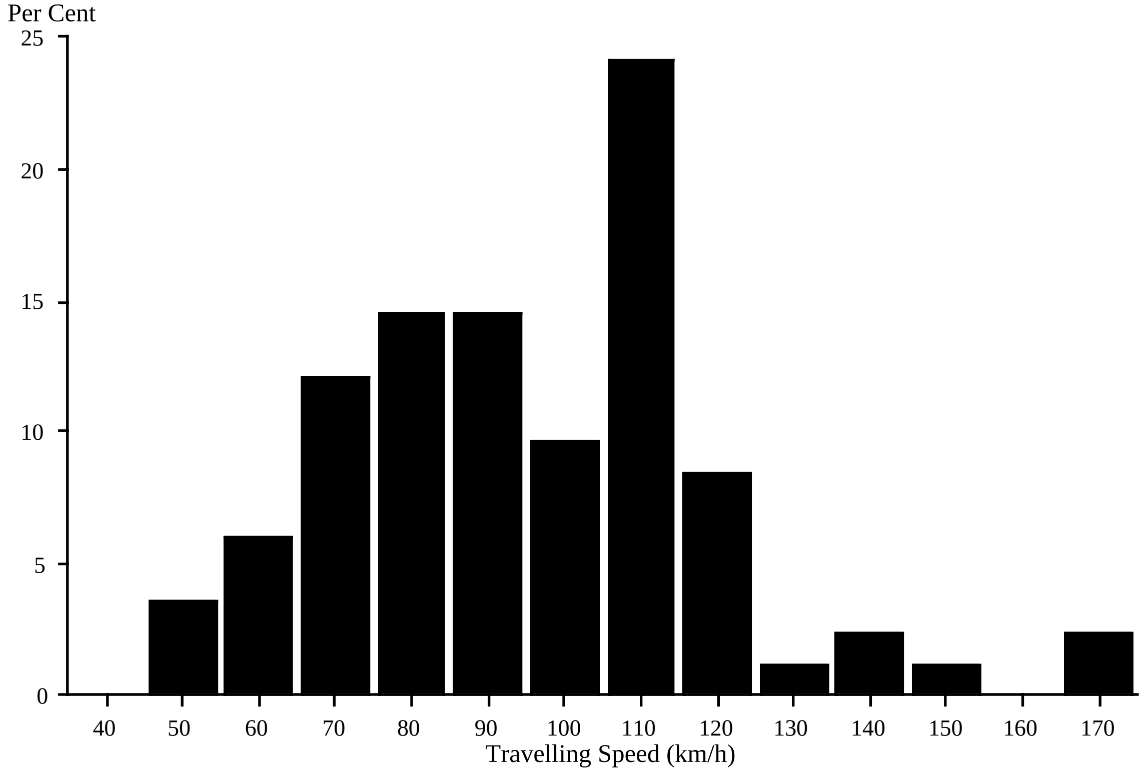


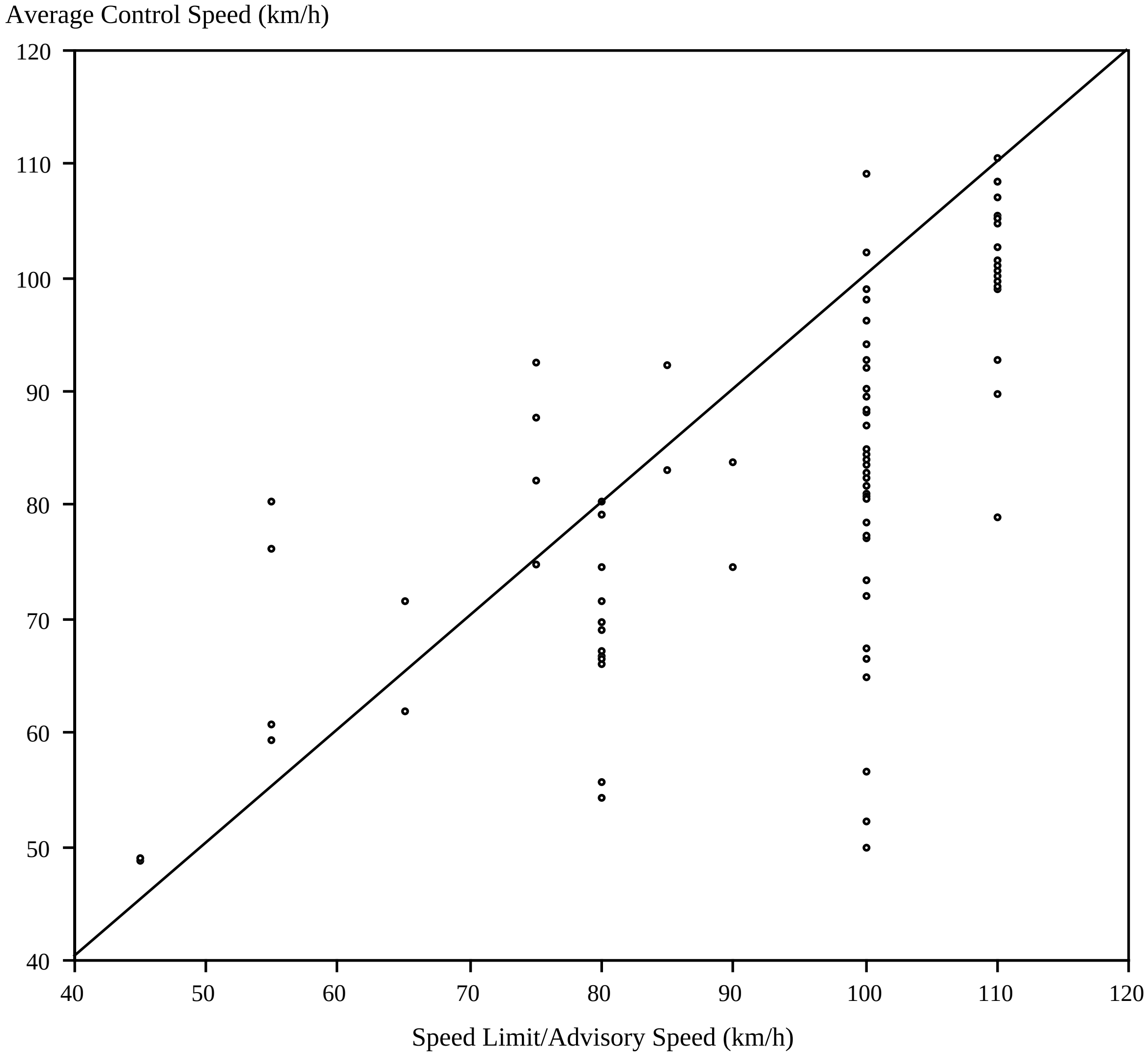
Figure 3.2
Case Vehicle Travelling Speeds (n=83)



3.6 Control Vehicle Speeds

The average of the 10 control speeds for each site is plotted against the speed limit/Advisory Speed in Figure 3.3. It can be seen that average speeds at the locations where there was an Advisory Speed sign (those speeds ending in a 5) were generally above the Advisory Speed. By contrast the average speeds at sites without Advisory Speed signs were generally below the posted speed limit.

Figure 3.3
Average Control Speed Related to Speed Limit/Advisory Speed



3.7 Case and Control Speed Difference Distributions

Due to the widely differing average control travelling speeds on the rural roads where the current set of crashes occurred (see Figure 3.3), it is not reasonable simply to compare case and control speeds to construct meaningful risk estimates.

After exploring various possible methods of normalising the data, it was decided to normalise both the case and control speeds at a given crash site by expressing them as a speed difference from the average of the control speeds at that site.

Figures 3.4 and 3.5 show the distributions of the control and case vehicle speed differences from the average control speed at each site. The control speed differences from the average control speed form a roughly bell shaped curve around a zero difference in travelling speed while the case speed differences from the average control speed are skewed towards positive speed differences.

Figure 3.4
Differences Between Control Vehicle Travelling Speeds and Average Control Speeds (n=830)

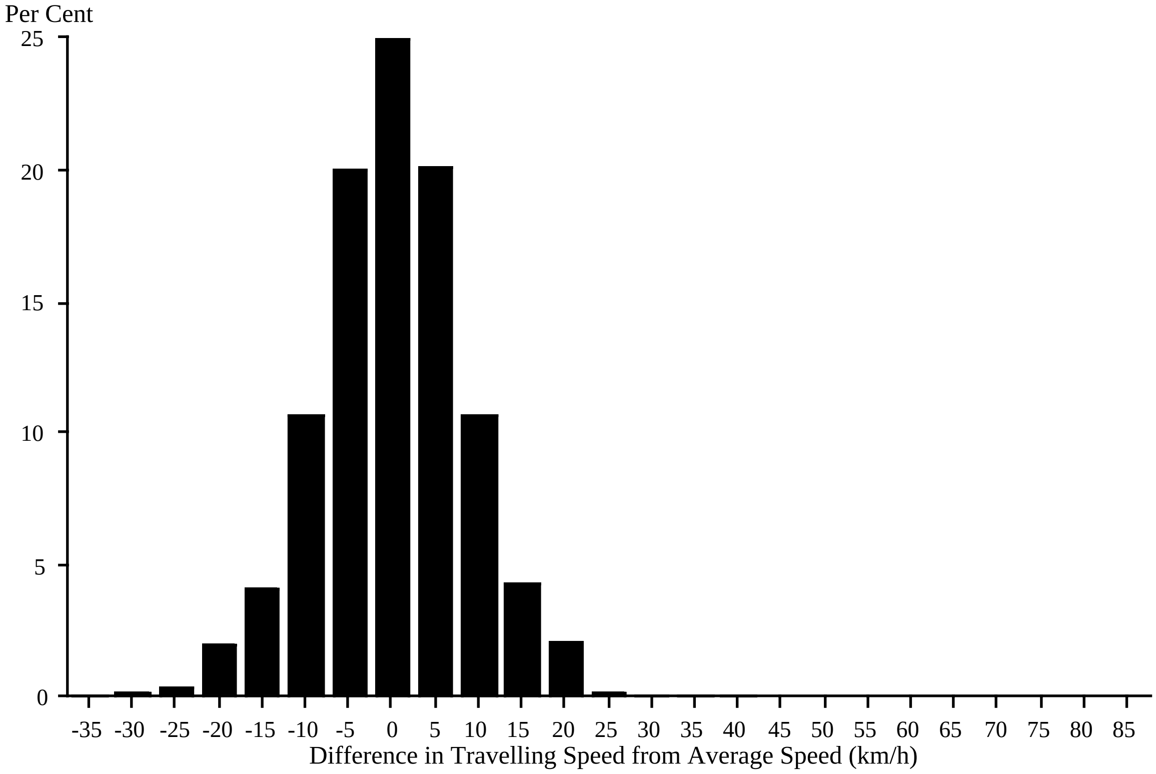
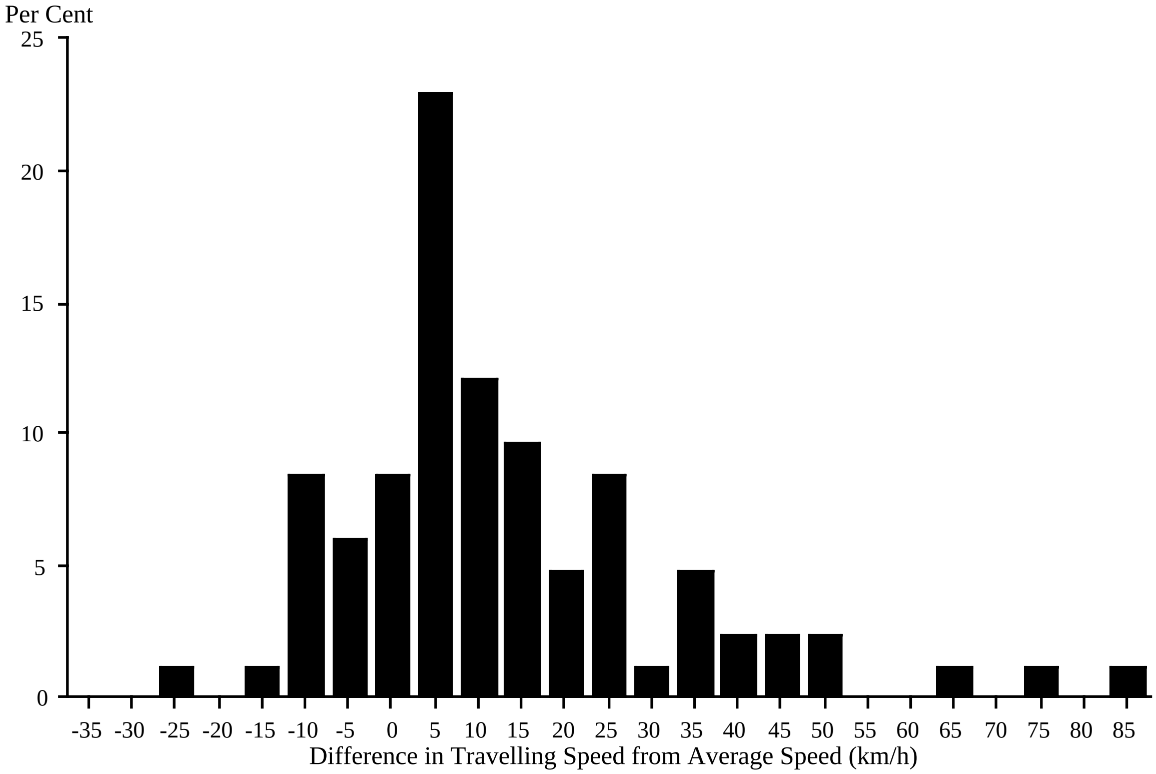


Figure 3.5
Differences Between Case Vehicle Travelling Speeds and Average Control Speeds (n=83)



3.8 Relative Crash Risk Estimates

In this section the risk of involvement in a casualty crash, relative to the risk at the average speed of the control vehicles, is calculated on the basis of differences between the speed of the case vehicle and the average control speed at each crash location.

Modified logistic regression modelling was used to establish the shape of the casualty crash relative risk curve (contact the Road Accident Research Unit for details). One of the modifications involved allowing for any uncertainty in the estimation of the case vehicle speeds. While the control vehicle speeds were measured very accurately using a laser speed meter, the case vehicle speeds had to be estimated using reconstruction techniques that by their nature cannot give consistently precise results. The model used allowed for this uncertainty by assuming a standard error for the case vehicle speeds of 5 km/h. This equates to stating that 70 per cent of our estimated case vehicle travelling speeds were within 5 km/h of the actual travelling speed. We consider this to be a reasonable assumption based on our experience with the crash reconstruction methods used. Alternative curves based on different standard error assumptions and using the grouping method are given in Appendix A.

The data (given in raw form in Appendix B) were fitted using a range of logistic regression models and a quadratic model was found to provide a good fit for speed differences between –10 and +30 km/h. The estimated coefficients in the quadratic model were found to be highly statistically significant ($p<0.001$). Semi-parametric testing also showed that the quadratic model provided a reasonable fit for speed difference from –20 to +40 km/h. Ninety five per cent confidence intervals were calculated using a simulation method. As can be seen in Appendix A, all of the logistic models considered give very similar results and also compare well with the grouping method used in the previous urban speed study (Kloeden et al. 1997).

The final equation obtained for the relative risk of casualty crash involvement at a given difference from the mean traffic speed (valid for speed differences from -10 to +30 km/h) is:

$$\text{relative risk (speed difference)} = e^{(0.07039V + 0.0008617V^2)}$$

where V = difference in travelling speed in km/h

As an example of how this equation is applied, a vehicle that travels in a rural area at a speed 10 km/h faster than the average speed of the rest of the traffic will have a risk of crashing that is 2.2 times greater than a vehicle that travels at the same speed as the average speed of the rest of the traffic. Note that this estimate of the relative risk only applies to vehicles that are travelling at a free speed.

The risk estimates derived from the above equation for a range of speed differences are presented in Table 3.14 together with the 95 per cent confidence intervals calculated using simulation.

Table 3.14
Differences Between Case Vehicle Travelling Speed and Average Control Speed and the Risk of Involvement in a Casualty Crash Relative to Travelling at the Average Control Speed

Speed Difference*	**Relative Risk**	**Lower Limit****	**Upper Limit****
-10	0.54	0.33	0.76
-5	0.72	0.58	0.83
0	**1**	**1**	**1**
5	1.45	1.30	1.71
10	2.20	1.79	2.95
15	3.49	2.57	5.35
20	5.77	3.80	10.57
25	9.96	5.69	23.70
30	17.94	8.45	60.21

* Difference of case and control speeds from average control speed at given sites (km/h)
** 95% confidence limits of the estimated relative risk
*** Relative risk arbitrarily set to 1 for zero difference between case vehicle travelling speed and average control speed at given sites

This method of calculating relative risks makes use of the fact that crash involvement is a rare event. The 'risks' in Table 3.14 are actually the relative odds of involvement in a casualty crash. However, the relative odds are virtually the same as the relative risk when dealing with rare events (MacMahon and Pugh, 1970).

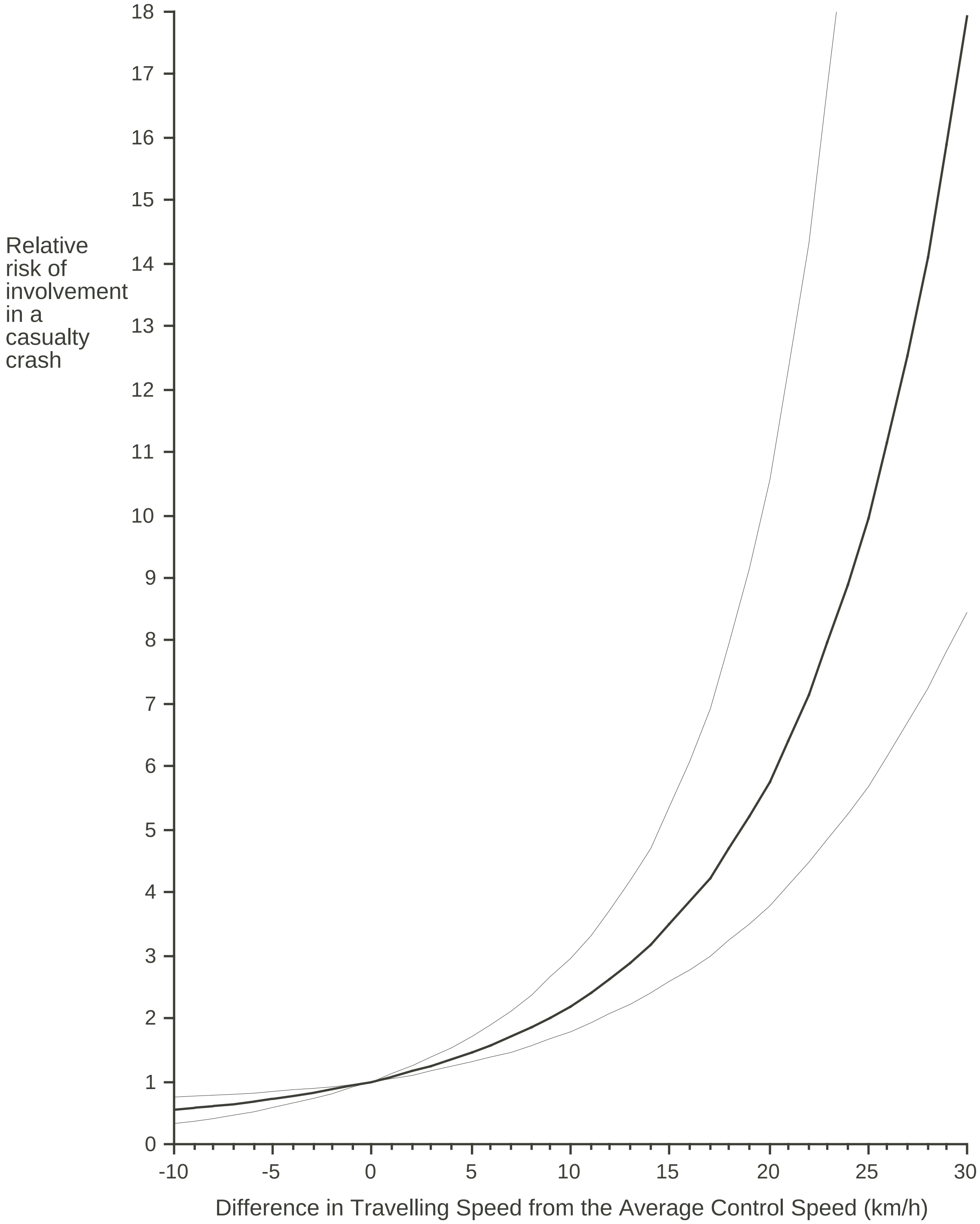
While the relationship between differences in travelling speed and relative risk was found to be highly statistically significant, it is not certain that the estimate of relative risk obtained is an accurate representation of the 'real' relative risk (as in any estimate of this type). However, confidence limits give the range of values that probably include the 'real' relative risk and the limits of this range are shown in Table 3.14. For the 10 km/h speed difference example, the 95% confidence limits are 1.79 and 2.95. This means that it can be claimed with 95 per cent confidence that the 'real' relative risk lies within the range from 1.79 to 2.95.

A statistically significant relationship is not necessarily large enough to be of practical importance. The results listed in Table 3.14, however, show that even a free travelling speed difference of 10 km/h more than doubles the risk of involvement in a casualty crash. An increase in risk of that magnitude is clearly of practical importance.

The data also suggest that there is a safety benefit in travelling slower than the average speed of other vehicles at least down to 10 km/h slower. Below 10 km/h slower there was insufficient data available to draw any meaningful conclusions although the risk appeared to continue decreasing down to 20 km/h slower.

The information in Table 3.14 is presented graphically in Figure 3.6.

Figure 3.6
Differences Between the Travelling Speed and Average Control Speed and the Risk of Involvement in a Casualty Crash Relative to Travelling at the Average Control Speed



Note: 95 per cent confidence intervals are shown by the thin lines

3.9 Hypothetical Scenarios

Additional information about the relationship between travelling speed and crash involvement was obtained by calculating what the likely change in the expected number of rural casualty crashes would have been if the vehicles in this study had been travelling at different speeds.

The following hypothetical Scenarios were examined:

1. Uniform 5 km/h speed reduction applied to all free travelling speed vehicles
2. Uniform 10 km/h speed reduction applied to all free travelling speed vehicles
3. Uniform 20 km/h speed reduction applied to all free travelling speed vehicles
4. No free travelling speed vehicles travelling above the average speed of the control vehicles
5. Total compliance with speed limits by all free travelling speed vehicles
6. Total compliance with Advisory Speed signs by all free travelling speed vehicles
7. Maximum speed limit reduced to 80 km/h on all undivided roads with similar compliance to that at present

Under Scenario 1, all free travelling speed vehicles were assumed to have a travelling speed 5 km/h less than their calculated travelling speed.

Under Scenario 2, all free travelling speed vehicles were assumed to have a travelling speed 10 km/h less than their calculated travelling speed.

Under Scenario 3, all free travelling speed vehicles were assumed to have a travelling speed 20 km/h less than their calculated travelling speed.

Under Scenario 4, all free travelling speed vehicles with a calculated travelling speed above the average speed of the control vehicles at a given crash site were assumed to be travelling at the average speed of the control vehicles at that site.

Under Scenario 5, all free travelling speed vehicles with a calculated travelling speed above the speed limit were assumed to be travelling at the speed limit.

Under Scenario 6, all free travelling speed vehicles subject to an Advisory Speed sign with a calculated travelling speed above the Advisory Speed were assumed to be travelling at the Advisory Speed.

Under Scenario 7, all free travelling speed vehicles that were travelling in 80 km/h speed zones or on divided roads did not have their speeds changed; all free travelling speed vehicles on undivided roads where the speed limit was 90 km/h or greater which were travelling at an estimated speed between 80 km/h and the speed limit had their speeds set to 80 km/h; all free travelling speed vehicles on undivided roads where the speed limit was 90 km/h or greater which were travelling at an estimated speed above the speed limit had their speeds reduced by the difference between the speed limit and 80 km/h (eg a vehicle travelling at 125 km/h in a 100 km/h zone had its hypothetical speed reduced to 105 km/h); the speeds of vehicles travelling below 80 km/h were unchanged. This scenario was intended as a first approximation estimate of the effect of reducing the maximum speed limit on undivided roads to 80 km/h.

For each of the Scenarios, all 167 rural crashes attended in this study were examined. The crash risk of the following categories of vehicles was assumed not to change under any of the hypothetical Scenarios:

- A vehicle with an alcohol intoxicated driver (this is conservative since travelling at a slow speed would certainly aid even an intoxicated driver to some extent)
- A vehicle crashing because of a driver's medical condition, such as a blackout or heart attack (again this is conservative)
- A vehicle with a driver attempting suicide
- A vehicle with a driver that fell asleep
- A vehicle not travelling at a free speed (eg overtaking, following, accelerating, slowing, stopped, or turning)
- A vehicle executing an illegal manoeuvre (eg failing to give way)
- A slow moving tractor towing a trailer, and a bicycle

The following additional assumptions were also made:

- Trucks and motorcycles had the same speed distribution and speed risk curve as passenger vehicles
- Any speed more than 20 km/h below the mean control speed was set to -20 km/h for the calculation of a relative risk (this conservative approach was taken due to the lack of available data defining the risk curve below this speed)

After applying these assumptions, all of the 167 crashes fell into one of 11 categories. The method for calculating the probability of a casualty crash occurring under the hypothetical Scenario given that a casualty crash happened in actuality for each of the categories is shown below. Note that for these purposes, vehicles with "free travelling speeds" assumed not to change under the Scenarios for the reasons listed above are treated here as non-free travelling speed vehicles.

Category 1 (27 crashes):
In a free travelling speed single vehicle crash where the travelling speed was estimated, the probability of that crash happening under the hypothetical Scenario was calculated as the relative risk associated with the hypothetical speed divided by the relative risk associated with the actual speed.

Category 2 (26 crashes):
In a free travelling speed single vehicle crash where the travelling speed was not estimated, the probability of that crash happening under the hypothetical Scenario was set to the average probability of all Category 1 crashes.

Category 3 (24 crashes):
In a single vehicle crash where the vehicle was not travelling at a free speed the probability of that crash happening under the hypothetical Scenario was set to 1.

Category 4 (7 crashes):
In a two vehicle crash where both the vehicles were travelling at a free speed and both travelling speeds were estimated, the probability of each of the vehicles crashing under the hypothetical Scenario was calculated as the relative risk associated with its hypothetical speed divided by the relative risk associated with its actual speed. The two probabilities of crashing for both vehicles were than multiplied together to give the probability of that crash happening under the hypothetical Scenario.

Category 5 (3 crashes):
In a two vehicle crash where both the vehicles were travelling at a free speed but only one had an estimated travelling speed, the probability of that vehicle crashing under the hypothetical Scenario was calculated as the relative risk associated with its hypothetical speed divided by the relative risk associated with its actual speed. This probability was then squared to give the probability of the crash happening under the hypothetical Scenario.

Category 6 (8 crashes):
In a two vehicle crash where both the vehicles were travelling at a free speed but both of these speeds were unknown, the probability of that crash happening under the hypothetical Scenario was set to the average probability of all Category 4 crashes.

Category 7 (38 crashes):
In a two vehicle crash where only one vehicle was travelling at a free speed and that speed was estimated, the probability of that crash happening under the hypothetical Scenario was calculated as the relative risk associated with the free travelling speed vehicle's hypothetical speed divided by the relative risk associated with its actual speed.

Category 8 (23 crashes):
In a two vehicle crash where only one vehicle was travelling at a free speed and that speed was unknown, the probability of that crash happening under the hypothetical Scenario was set to the average probability of all Category 7 crashes.

Category 9 (9 crashes):
In a two vehicle crash where neither vehicle was travelling at a free speed, the probability of that crash happening under the hypothetical Scenario was set to 1.

Category 10 (1 crash):
In the three vehicle crash where two of the vehicles had a free travelling speed but only one of these speeds was able to be estimated, that vehicle's probability of crashing under the hypothetical Scenario was calculated as the relative risk associated with its hypothetical speed divided by the relative risk associated with its actual speed. This probability was then squared to give the probability of the crash happening under the hypothetical Scenario.

Category 11 (1 crash):
In the three vehicle crash where one of the vehicles had a free travelling speed and this speed was unknown, the probability of that crash happening under the hypothetical Scenario was set to the average probability of all Category 7 crashes.

After applying the calculations above to all 167 crashes for each of the Scenarios, the expected number of crashes was summed to give a total expected number of crashes. The percentage reduction in this set of rural crashes expected under the hypothetical Scenario was then calculated. The results for the various Scenarios are shown in Table 3.15.

Table 3.15
Reductions in Rural Casualty Crashes Under Hypothetical Scenarios

Hypothetical Scenario	**%Reduction in Rural Casualty Crashes**
5 km/h free travelling speed reduction	30.5
10 km/h free travelling speed reduction	46.5
20 km/h free travelling speed reduction	59.6
No speeds above control average	41.0
Total compliance with speed limits	23.8
Total compliance with Advisory Speed signs	8.4
80 km/h maximum speed limit on undivided roads with compliance as at present	32.4

It can be seen in Table 3.15 that a large proportion of the casualty crashes attended in this study would have been avoided had the free travelling speed vehicles been travelling at a slower speed. Even a 5 km/h reduction in the speed of all the rural free travelling speed vehicles would lead to a 31 per cent reduction in these casualty crashes. It was also found that 24 per cent of all the casualty crashes investigated would have been avoided if none of the vehicles had been travelling above the speed limit and that lowering the maximum speed limit on undivided roads to 80 km/h could be expected to lower casualty crash frequency by 32 per cent.

4. DISCUSSION

As noted in the Introduction, the main aim of this study was to quantify the relationship between free travelling speed and the risk of involvement in a casualty crash, for sober drivers of passenger vehicles in a rural out of town setting. The secondary aim of the study was to examine the likely effect of hypothetical speed reductions on the frequency of rural casualty crashes involving passenger vehicles.

4.1 Travelling Speed and the Risk of Involvement in a Casualty Crash

As shown in Table 3.14 and Figure 3.6, the risk of a passenger vehicle being involved in a casualty crash, relative to the risk for a passenger vehicle travelling at an average speed, increased at a greater than exponential rate with increasing free travel speed above the average speed of passenger vehicles on the road.

Conversely, travelling speeds slower than average vehicle travelling speeds were associated with a lower relative risk of casualty crash involvement (at least down to 10 km/h slower). There was no indication of a U–shaped distribution whereby low travelling speeds are associated with an increased risk even though the quadratic model used allowed for such a pattern to be expressed.

4.2 Reasons for Increase in Risk with Increase in Travelling Speed

While this study was not designed to investigate the mechanisms by which increases in travelling speed lead to increases in crash risk, a number of possible mechanisms are apparent.

4.2.1 Loss of Control

Some of cars involved in crashes in this study were travelling at very high speeds (greater than 30 km/h above the average speeds of the control vehicles at the crash site) when the driver lost control of the vehicle. This coupled with the almost total absence of any of the cars not involved in crashes travelling at these speeds, indicates that very high speeds are associated with extremely high risks of losing control of the vehicle and subsequent crashes and injuries.

Even less excessive speeds can also be associated with loss of control. A common crash sequence seen in this study was of a vehicle running partly on to the unsealed shoulder to the left of the road, overcorrecting back on to the roadway, and then either running off the right side of the road, colliding with an oncoming vehicle, or overcorrecting back to the left again. It is at least conceivable that, had the vehicle been travelling slower, the driver may not have run onto the shoulder in the first place, or not lost control on attempting to return to the sealed carriageway.

4.2.2 Reaction Distance and Braking Distance

The average time taken by a driver to identify that a crash is likely, decide on avoiding action, and implement that action is about 1.5 seconds (see McLean, Anderson, Farmer, Lee and Brooks, 1994). The reaction distance is that distance travelled by the vehicle in this 1.5 seconds and is directly proportional to the travelling speed of the vehicle. At 100 km/h it is 42 metres; at 120 km/h it is 50 metres. While this difference in reaction distance is only 8 metres, a car travelling at 100 km/h and skidding to a stop just in front of a tree would hit the tree at 38 km/h if it was 8 metres closer when it started braking from 100 km/h.

In the absence of antilock brakes (which were rare among the vehicles in this study), braking in an emergency results in the wheels locking and the vehicle skidding, even for highly skilled drivers. (An emergency situation in normal traffic is, by definition, unanticipated, unlike some apparently similar situations on the race track.) Skidding under emergency braking is accompanied by the loss of steering control and hence the loss of any ability to steer away from an object in the path of the vehicle.

Braking distance, from travelling speed to a standstill, is proportional to the square of the speed. From 100 km/h the braking distance is 58 metres, from 120 km/h it is 80 metres (on a dry sealed road surface with a coefficient of friction of 0.7). When the reaction distance is added to the braking distance, it can be seen that from 100 km/h it requires 100 metres to stop in an emergency, whereas from 120 km/h, 130 metres are needed (a 30% increase).

However, this comparison understates the importance of a 20 km/h difference in travelling speed. For example, consider two cars that are travelling side by side at a given instant, one travelling at 100 km/h and the other overtaking at 120 km/h. Suppose that another vehicle pulls out onto the road at a point just beyond that at which the car travelling at 100 km/h can stop. The other car will still be travelling at 73 km/h at that point. A difference in travelling speed of 20 km/h can mean a difference between no impact at all and an impact at a speed of 73 km/h.

4.2.3 Impact Speed and Crash Energy

The kinetic energy of a vehicle that must be dissipated in a crash is proportional to the square of the speed of the vehicle at impact. This means that small differences in impact speed are associated with large differences in crash energy, and correspondingly large differences in injury potential.

4.2.4 Driver Expectancies

It is likely that a vehicle that is travelling unusually fast may create a dangerous situation. This can happen when another driver assumes that the approaching speeding car is travelling at about the same speed as other traffic on that road. This is especially important when drivers have to judge the speed of a vehicle coming directly towards them as they only have the small increase in apparent size of the vehicle as it approaches to judge the vehicle's speed.

4.2.5 Combination of Factors

The factors discussed here often have a cumulative, and probably a synergistic effect on the risk of involvement in a casualty crash. For example, a speeding vehicle is likely to have its speed misjudged by another driver, thereby creating a crash situation, in which the speeding vehicle will travel further during the reaction time of its driver, will lose less speed in the available distance under emergency braking, and will crash at a comparatively greater speed with much greater crash energy.

These factors are based mainly on physical and physiological principles that are not influenced by the skill, or lack thereof, of the driver of the speeding vehicle. This has two important implications. The first is that no driver can control the failure of other drivers to realise that a vehicle is approaching at a faster speed than experience has taught them to expect. The second is that if an "advanced" driver training course encourages a driver to believe that he or she has become more capable of controlling a car in an emergency situation at speed (despite the fact that Newton's Laws of Motion are not affected by such tuition) it may in fact increase the likelihood that the course graduate will choose to travel faster than would otherwise be the case and thereby unwittingly create emergency situations of the type referred to here.

4.3 Validity of the Risk Estimates

The above results are presented as best estimates of the relationship between free travelling speed in a rural area and the risk of involvement in a casualty crash. We are aware of a number of matters which could have affected the validity of the risk estimates and they are discussed here.

4.3.1 Crash Severity

While we have attempted to obtain a reasonably representative sample of rural casualty crashes, the average severity of the sample of crashes investigated here was greater in terms of injury outcome than rural crashes in general. If higher travelling speeds are associated with more serious crashes then the current analysis may introduce a bias towards higher risk estimates for casualty crashes as a whole. Since the existence or size of this effect is unknown it is more precise to say that that our risk estimates are based on a higher than average level of casualty crash severity. By the same logic, the relationship between speed and risk of a fatality crash may be significantly steeper than the estimates presented here.

The Adelaide in-depth accident study is an example of the type of study design needed to be confident of obtaining a representative sample of crashes (McLean and Robinson, 1979). The approach adopted for the current study relied on the fact that we usually did not know the type or severity of the accident we were responding to when we were notified of its occurrence by the ambulance service. However, in more serious crashes the scene tended to stay intact for a longer period of time and so they were more likely to be included in the study. In fatal cases, as noted earlier, the crash scene was often marked up by Police Major Crash, which enabled our investigation to commence on the following day.

4.3.2 Excluded Cases

A number of vehicles that met the basic selection criteria for the study had to be excluded from the analysis because the travelling speed could not be reconstructed or comparable controls could not be collected. Where this exclusion was potentially related to travelling speed it may have been a source of bias. For example, the speeds of crash involved vehicles on rarely travelled sections of rural roads may be quite different from those on more heavily travelled sections of rural roadway. However, the existence and size of any such effects (and their potential influence on the reported risk estimates) is unknown and so cannot be accounted for.

4.3.3 Case Vehicle Speed Calculation

The validity of the risk estimates depends, among other factors, on the accuracy of the reconstruction of the travelling speed of the case vehicles. While non-systematic errors were accounted for in the logistic regression analysis and are shown to have little effect on the results (see Appendix A), systematic errors have the potential to result in biased estimates.

The crash reconstruction method used in this study depends primarily on the physical evidence left at the scene after the crash event. The greatest potential for bias in this respect is due to the inability of the method to take into account speed lost before impact due to braking without leaving skid marks. It is possible that some proportion of the case vehicles included in the study that showed no physical evidence of braking before impact actually did brake without leaving skid marks. This would mean that their travelling speeds would have been underestimated, leading to a bias in the overall risk estimate.

There were also a few crashes where the damage to the vehicles indicated that the case vehicle was braking at impact (eg: lower than usual front bumper height) but there was no other physical evidence, such as skid marks, of braking at the scene. In this situation, the case was rejected because while it was known that speed was lost before impact, the amount of speed lost could not be quantified. If these potential cases differed systematically in their travelling speed from the other cases, their exclusion could have biased the risk estimates. However, we are not aware of any reason to believe that such a bias exists.

It is emphasised that the travelling speed listed for each case is our best estimate of the actual speed. We believe that we have made use of the best available methods of crash reconstruction, both computer-aided and in interpretation of the physical evidence at the crash scene and the damage to the vehicles involved. Nevertheless we recognise that the final decision on the travelling speed of a case vehicle is a matter of judgement that may have involved some unknown bias on the part of the investigators.

4.3.4 Risk Factors Other than Travelling Speed

It may be that drivers who choose to travel faster than most other drivers on a specific section of road also exhibit other risk taking behaviour. It may be, therefore, that some of the increase in risk seen in this study is due to this risk taking behaviour and not solely to the higher travelling speed itself. However, the study design largely controlled for one of the other main forms of risk taking, alcohol impaired driving.

4.4 Comparisons with Other Research

4.4.1 Previous Rural Speed Case Control Studies

Previous case control studies of rural travelling speed and crash risk (Solomon, 1964; Cirillo, 1968; Research Triangle Institute, 1970) have, to varying degrees, found a U-shaped risk curve for speed and crash risk. This led to the belief by many traffic engineers that it is more important to get vehicles to travel at similar speeds (ie: reduce the variance in travelling speeds) than to reduce the average speed of traffic in order to reduce the number of crashes. As has been discussed in the introduction to this report, and in many other publications (eg: Transportation Research Board, 1998), fundamental methodological biases in these studies can be expected to lead to an artifactual U-shaped risk curve.

The current study has attempted to address all these methodological issues and there is no evidence of a U–shaped curve. This supports the conclusion that the U-shaped curve resulted from artefacts in earlier study designs.

4.4.2 Urban Crash Risks

The previous urban speed and crash risk study (Kloeden, McLean, Moore and Ponte, 1997) on which the current study is based found that in a 60 km/h speed limit area, the risk of involvement in a casualty crash was found to approximately double with each 5 km/h increase in travelling speed above 60 km/h. The increase in risk with increasing speed in the current study was not as pronounced with a doubling of risk being associated with vehicles travelling 10 km/h faster than the rest of the traffic at a particular crash site. There are a number of possible explanations for this difference.

In urban areas the frequency of interaction with other vehicles and, in particular, with turning vehicles is much greater and so small differences in travelling speed can have larger effects on the risk of involvement in a casualty crash than on rural roads with fewer intersections and lower traffic volumes. Moreover, if speed increments are expressed in proportional rather than absolute terms, the differences between the urban and rural results become much less pronounced.

4.5 Hypothetical Travelling Speed and Crash Severity

A large proportion of the casualty crashes attended in this study would have been avoided had the free travelling speed vehicles been travelling at a slower speed. Even a 5 km/h reduction in the speed of all the rural free travelling speed vehicles would lead to a 31 per cent reduction in these casualty crashes. It was also found that 24 per cent of all the casualty crashes investigated would have been avoided if none of the vehicles had been travelling above the speed limit and that lowering the maximum speed limit on undivided roads to 80 km/h could be expected to lower casualty crash frequency by 32 per cent. This indicates the considerable safety benefits possible from a reduction in rural travel speeds.

While most of the mechanisms for increased crash risk with increasing speed postulated in Section 4.2 deal with the effects of absolute speed, the driver expectancy effect deals with the difference between a vehicle's speed and the average speed of all vehicles whereby a driver underestimates an approaching vehicle's speed and crosses its path creating a crash situation. Under the first 3 hypothetical scenarios dealing with uniform reductions in travelling speed, there would be no reduction in speed differences and so no reduction in this effect which means that the reductions calculated are overestimates. However, only a minority of crashes are subject to this effect and the other absolute speed mechanisms will still apply even in these crashes so the effect size is believed to be small. Under the remaining hypothetical scenarios, speed differences are all reduced so a driver expectancy effect will apply although not necessarily at the strength implicitly calculated in the risk curve.

The hypothetical method used here also involves extending the calculated risk curve to large positive speed differences even though the risk curve really only fits speed differences between -10 and +30 km/h (although the data are consistent for speed differences from -20 to +40 km/h). While this extension can be questioned, it is necessary for the hypothetical calculations and represents the best available method given the limited amount of data available.

For negative speed differences, a conservative approach was taken by setting any speed difference below -20 km/h to -20 km/h.

In light of these limitations, the hypothetical estimates should be considered as reasoned approximations of the probable effects of the scenarios.

5. CONCLUSIONS AND RECOMMENDATIONS

In rural out of town areas, the risk of involvement in a casualty crash increases at a rate greater than exponentially with increasing free travel speed. Even travelling just 10 km/h faster than the average speed of other traffic was found to double the risk of crash involvement.

It was also found that small reductions in travelling speed in rural areas have the potential to greatly reduce casualty crashes in those areas and that illegal speeding causes a significant proportion of rural crashes.

We therefore recommend that:

1. The level of enforcement of speed limits in rural areas be increased.

2. The tolerance allowed in the enforcement of rural speed limits be reduced or eliminated.

3. All currently zoned 110 km/h undivided roads be rezoned to no more than 100 km/h.

4. Speed limits be reduced where current limits are considerably greater than average travelling speeds and where there are frequently occurring Advisory Speed signs.

5. After a period with stricter enforcement of rural area speed limits, consideration be given to changing the maximum speed limit to 80 km/h on all two lane rural roads, as is the practice on two lane rural roads in many States in the USA.

6. The level of public awareness of the risk of involvement in a casualty crash associated with speeding be increased with the aim of developing a culture of compliance with speed limits, and support for strict limits, similar to that which has developed in relation to compliance with blood alcohol limits during recent decades.

7. To assist with the preceding recommendation, we also recommend that the results of this study be widely publicised.

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APPENDIX A - Alternate Risk Estimation Methods

Risks Calculated Using the Grouping Method

Table A.1 shows the relative risk calculations using the grouping method used in the previous urban speed study (Kloeden, McLean, Moore and Ponte, 1997) modified to use speed differences rather than absolute speeds. While the modified logistic regression model actually used in this study has the advantages of fitting the data as a whole without categorisation, producing an equation for the risk curve and allowing uncertainties in the case speed estimates to be taken into account, it is heartening that those results (see Table 3.14) are still readily comparable to those obtained using the grouping method. This indicates that the data are robust.

Table A.1
Differences Between Case Vehicle Travelling Speed and Average Control Speed and the Risk of Involvement in a Casualty Crash Relative to Travelling at the Average Control Speed

Speed Difference*	No. of Cases	No. of Controls	Relative Risk	Lower Limit**	Upper Limit**
-30	0	5	0.00	-	-
-20	1	29	0.63	0.08	4.83
-10	9	183	0.90	0.40	1.99
0	**22**	**401**	**1*** **		
10	23	174	2.41	1.31	4.44
20	10	34	5.36	2.35	12.24
30	8	3	48.61	12.05	196.05
40	3	1	54.68	5.46	547.34
50	4	0	infinite	-	-
60	1	0	infinite	-	-
70	1	0	infinite	-	-
80	1	0	infinite	-	-
Total	**83**	**830**			

* Difference of case and control speeds from average control speed at given sites (km/h)
** 95% confidence limits of the estimated relative risk
*** Relative risk arbitrarily set to 1 for zero difference between case vehicle travelling speed and average control speed at given sites

Risks Calculated Using Different Standard Errors for the Case Speeds

As noted in the Results Section 3.8, a modification was made to the logistic regression model that involved allowing for any uncertainty in the estimation of the case vehicle speeds. It was noted there that while the control vehicle speeds were measured very accurately using a laser speed meter, the case vehicle speeds had to be estimated using reconstruction techniques that by their nature cannot give consistently precise results.

The actual model used allowed for this uncertainty by assuming a standard error for the case vehicle speeds of 5 km/h. This equates to stating that 70 per cent of our estimated case vehicle travelling speeds were within 5 km/h of the actual travelling speed. While we considered this to be a reasonable assumption based on our experience with the crash reconstruction methods used we cannot validate its accuracy.

In order to get a feel for the effects of this factor on the resulting risk curve, the analysis was re-run using extreme standard errors of 0 and 10. The resulting Tables A.2 and A.3 show that while this factor does have an effect at these extreme levels, the effect does not change the fundamental shape of the relative risk curve. This again gives an increased sense of robustness to the results.

Table A.2
Differences Between Case Vehicle Travelling Speed and Average Control Speed and the Risk of Involvement in a Casualty Crash Relative to Travelling at the Average Control Speed Assuming a Standard Error for Case Speeds of 0 km/h

Speed Difference*	Relative Risk	Lower Limit**	Upper Limit**
-10	0.62	0.38	0.88
-5	0.76	0.61	0.89
0	**1**	**1**	**1**
5	1.40	1.25	1.65
10	2.08	1.69	2.79
15	3.31	2.44	5.08
20	5.63	3.71	10.32
25	10.22	5.85	24.33
30	19.82	9.33	66.49

* Difference of case and control speeds from average control speed at given sites (km/h)
** 95% confidence limits of the estimated relative risk
*** Relative risk arbitrarily set to 1 for zero difference between case vehicle travelling speed and average control speed at given sites

Table A.3
Differences Between Case Vehicle Travelling Speed and Average Control Speed and the Risk of Involvement in a Casualty Crash Relative to Travelling at the Average Control Speed Assuming a Standard Error for Case Speeds of 10 km/h

Speed Difference*	Relative Risk	Lower Limit**	Upper Limit**
-10	0.29	0.18	0.42
-5	0.55	0.44	0.64
0	**1**	**1**	**1**
5	1.73	1.55	2.05
10	2.88	2.35	3.87
15	4.60	3.40	7.05
20	7.04	4.63	12.91
25	10.34	5.91	24.60
30	14.55	6.86	48.83

* Difference of case and control speeds from average control speed at given sites (km/h)
** 95% confidence limits of the estimated relative risk
*** Relative risk arbitrarily set to 1 for zero difference between case vehicle travelling speed and average control speed at given sites

APPENDIX B - Raw Vehicle Data

The following Table gives all the raw vehicle data collected for this study. The columns are defined as follows:

Case:	Case number consisting of a crash number followed by a vehicle number after the dash
Road:	Road type S2U = sealed two lane undivided SMU = sealed multi-lane undivided SMD = sealed multi-lane divided U2U = unsealed two lane undivided
Type:	Crash type as used in the hypotheticals F = free travelling speed vehicle involved with an estimated free travelling speed available U = free travelling speed vehicle with no estimated speed available N = non-free travelling speed vehicle (as defined for hypotheticals)
Limit:	Speed limit at location of crash (km/h)
Adv:	Advisory speed at location of crash (km/h)
Severity:	Maximum injury severity in crash fatal = fatal injury (within 30 days of crash) admit = hospital admission treat = hospital treatment
Unit:	Vehicle type car = car sw = station wagon ute = utility panel = panel van 4wd = for wheel drive pvan = passenger van truck = truck semi = semitrailer mc = motorcycle bicycle = bicycle tractor = tractor
Free:	Whether the vehicle was travelling at a free travelling speed yes = vehicle was travelling at a free travelling speed accel = vehicle was accelerating decel = vehicle was decelerating follow = vehicle was following another vehicle overtak = vehicle was overtaking slow = vehicle was travelling slowly stopped = vehicle was stopped turn = vehicle was turning uturn = vehicle was executing a U-turn
Sober:	Alcohol use of driver yes = driver was sober no = driver had a positive alcohol level
Medical:	Driver suffered from medical condition blackout = driver blacked out heart = driver had a heart attack pain = driver suffered from intense pain sleep = driver fell asleep suicide = driver was attempting suicide
Illegal:	Driver was executing an illegal manoeuvre gway = driver failed to give way
Cont:	Control vehicle speeds could be collected for that vehicle yes = control vehicle speeds were obtained no = control vehicle speeds could not be obtained
Recon:	Free travelling speed could be estimated for that vehicle yes = a free travelling speed estimate was made no = a free travelling speed estimate could not be made
C1-C10:	Control speeds for that vehicle (km/h)
ConAve:	Average control speed (km/h)

Case	Road	Type	Limit	Adv	Severity	Unit	Free	Sober	Medical	Illegal	Cont	Recon	Speed	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	ConAve
R001-1	SMD	F	90		fatal	car	yes	yes			yes	yes	115	60	62	71	72	74	76	76	81	82	91	74.5
R003-1	S2U	FN	110		admit	car	yes	yes			yes	yes	112	98	101	105	107	111	111	111	113	113	115	108.5
R003-2	S2U	FN	110		admit	semi	turn	yes																
R004-1	S2U	FN	80	65	fatal	car	yes	yes			yes	yes	68	56	61	68	69	73	75	75	77	78	83	71.5
R004-2	S2U	FN	80	65	fatal	truck	yes	yes																
R005-1	S2U	F	110		fatal	pvan	yes	yes			yes	yes	115	100	100	102	102	103	105	107	108	111	114	105.2
R006-1	S2U	FN	110		fatal	4wd	yes	yes			yes	yes	106	94	100	104	111	112	113	115	116	119	121	110.5
R006-2	S2U	FN	110		fatal	car	turn	yes																
R008-1	S2U	N	110	45	admit	pvan	yes	yes		gway														
R009-1	S2U	FN	90		fatal	car	yes	yes			yes	yes	104	65	71	72	76	80	82	95	97	99	100	83.7
R009-2	S2U	FN	90		fatal	4wd	accel	yes																
R010-1	S2U	N	100		fatal	car	yes	no																
R011-1	S2U	F	100	55	fatal	car	yes	yes			yes	yes	75	63	69	71	73	76	79	79	81	83	87	76.1
R012-1	SMD	FN	110		admit	car	yes	yes			yes	yes	114	81	85	89	89	89	90	91	91	94	100	89.9
R012-2	SMD	FN	110		admit	car	turn	yes																
R014-1	S2U	F	110		admit	car	yes	yes			yes	yes	96	67	84	90	93	96	97	97	98	102	105	92.9
R015-1	U2U	N	80		admit	car	yes	no																
R016-1	U2U	UN	100		admit	mc	yes	yes																
R016-2	U2U	UN	100		admit	ute	stopped	yes																
R017-1	S2U	F	100		fatal	car	yes	yes			yes	yes	67	53	65	73	78	78	81	84	87	89	96	78.4
R018-1	S2U	FN	80		fatal	car	yes	yes			yes	yes	83	70	73	75	76	79	81	82	84	85	86	79.1
R018-2	S2U	FN	80		fatal	ute	yes	yes	sleep	gway														
R020-1	S2U	FN	100		admit	4wd	yes	yes			yes	yes	80	63	71	73	74	80	85	86	88	95	96	81.1
R020-2	S2U	FN	100		admit	car	yes	no																
R021-1	S2U	FN	100		admit	car	yes	yes			yes	yes	72	64	66	68	71	73	73	77	78	79	85	73.4
R021-2	S2U	FN	100		admit	sw	yes	yes		gway														
R022-1	S2U	F	100		admit	sw	yes	yes			yes	yes	143	76	79	85	87	87	90	100	102	111	112	92.9
R023-1	S2U	N	110		admit	car	yes	yes	blackout															
R024-1	S2U	F	100		admit	car	yes	yes			yes	yes	168	70	75	76	79	80	83	90	93	94	95	83.5
R026-1	S2U	N	80		treat	car	yes	no																
R027-1	U2U	UN	100		admit	car	yes	yes			no													
R027-2	U2U	UN	100		admit	car	yes	yes		gway														
R028-1	S2U	N	100	85	fatal	car	yes	no	sleep															
R031-1	S2U	FN	100		treat	car	yes	yes			yes	yes	68	35	51	53	54	55	56	57	61	69	75	56.6
R031-2	S2U	FN	100		treat	car	turn	yes																
R032-1	S2U	FN	100		treat	4wd	yes	yes			yes	yes	108	65	70	71	73	78	81	82	83	101	102	80.6
R032-2	S2U	FN	100		treat	ute	turn	yes																
R033-1	S2U	F	110		treat	car	yes	yes			yes	yes	118	91	96	101	102	103	105	105	105	108	137	105.3
R034-1	S2U	N	110		treat	car	overtak	no																
R037-1	S2U	N	100	55	admit	car	yes	no																
R039-1	S2U	U	100		treat	car	yes	yes				no												
R041-1	S2U	NN	100		treat	sw	follow	yes																
R041-2	S2U	NN	100		treat	sw	follow	yes																
R043-1	SMD	N	90		fatal	ute	yes	no																
R045-1	S2U	F	110	75	admit	car	yes	yes			yes	yes	114	74	74	77	78	82	85	94	99	105	110	87.8
R046-1	S2U	U	100	65	fatal	semi	yes	yes																
R048-1	S2U	U	100		admit	semi	yes	yes																
R049-1	S2U	FN	100		treat	car	yes	yes			yes	yes	94	71	71	84	86	86	88	95	101	102	111	89.5
R049-2	S2U	FN	100		treat	car	turn	yes																
R050-1	S2U	U	110	85	admit	semi	yes	yes																
R051-1	S2U	N	100	75	admit	car	yes	no																
R053-1	S2U	U	110	55	treat	semi	yes	yes																
R054-1	S2U	N	80		admit	car	yes	no	sleep															
R055-1	S2U	UN	110		fatal	ute	yes	yes	sleep	gway														
R055-2	S2U	UN	110		fatal	truck	yes	yes																
R056-1	S2U	F	110		admit	car	yes	yes			yes	yes	92	90	92	93	95	97	101	102	102	111	113	99.6
R057-1	S2U	NN	110		treat	4wd	decel	yes																
R057-2	S2U	NN	110		treat	car	follow	yes																
R059-1	S2U	FN	100	55	admit	ute	yes	yes			yes	yes	46	44	49	52	53	58	64	65	66	71	72	59.4
R059-2	S2U	FN	100	55	admit	car	yes	no																
R060-1	S2U	UN	110		treat	car	yes	yes			no													
R060-2	S2U	UN	110		treat	car	yes	yes		gway														
R062-1	S2U	FN	80		fatal	car	yes	yes			yes	yes	83	66	66	67	68	69	70	72	72	73	75	69.8
R062-2	S2U	FN	80		fatal	car	turn	yes																
R063-1	S2U	U	100		admit	sw	yes	yes				no												
R064-1	U2U	UU	100		admit	pvan	yes	yes				no												
R064-2	U2U	UU	100		admit	ute	yes	yes				no												
R065-1	SMD	NN	80		admit	car	accel	yes																
R065-2	SMD	NN	80		admit	car	uturn	yes																
R066-1	S2U	FN	100		treat	sw	yes	yes			yes	yes	114	63	65	70	70	75	76	77	88	93	95	77.2
R066-2	S2U	FN	100		treat	sw	uturn	yes																
R068-1	S2U	N	110		treat	car	slow	yes																
R069-1	S2U	FN	100		fatal	car	yes	yes			yes	yes	94	51	75	82	84	85	86	92	95	95	101	84.6
R069-2	S2U	FN	100		fatal	pvan	yes	yes	sleep	gway														
R071-1	S2U	U	100		admit	mc	yes	yes																
R072-1	U2U	UU	110		admit	car	yes	yes				no												
R072-2	U2U	UU	110		admit	car	yes	yes				no												
R073-1	SMD	F	110		admit	car	yes	yes			yes	yes	172	80	90	93	97	98	103	106	106	108	112	99.3
R074-1	S2U	N	110		fatal	semi	yes	yes	heart															
R075-1	U2U	UN	100		admit	car	yes	yes			no													
R075-2	U2U	UN	100		admit	car	yes	yes		gway														
R076-1	U2U	U	100		treat	car	yes	yes			no													
R077-1	S2U	FF	110		fatal	car	yes	yes			yes	yes	103	100	102	103	106	107	107	109	110	113	114	107.1
R077-2	S2U	FF	110		fatal	sw	yes	yes			yes	yes	106	80	88	95	98	100	103	105	106	112	114	100.1
R078-1	S2U	F	110		fatal	car	yes	yes			yes	yes	104	84	93	98	101	101	106	106	107	107	113	101.6
R079-1	S2U	U	90		admit	pvan	yes	no																
R080-1	S2U	UU	100	65	treat	pvan	yes	yes				no												
R080-2	S2U	UU	100	65	treat	car	yes	yes				no												
R081-1	S2U	NN	100		treat	sw	yes	no																
R081-2	S2U	NN	100		treat	car	stopped	yes																
R083-1	S2U	U	100	65	treat	car	yes	yes				no												
R086-1	S2U	FN	80		admit	car	yes	yes			yes	yes	111	62	66	68	70	70	71	75	76	77	80	71.5
R086-2	S2U	FN	80		admit	pvan	turn	yes																
R088-1	S2U	U	100		treat	4wd	yes	yes				no												
R090-1	SMD	FN	110		treat	car	yes	yes			yes	yes	90	88	90	92	97	99	100	103	106	115	117	100.7
R090-2	SMD	FN	110		treat	car	turn	yes																
R092-1	S2U	F	100		treat	car	yes	yes			yes	yes	99	78	79	81	83	90	96	98	104	104	128	94.1

Case	Road	Type	Limit	Adv	Severity	Unit	Free	Sober	Medical	Illegal	Cont	Recon	Speed	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	ConAve
R093-1	S2U	UN	110		fatal	4wd	yes	no		gway														
R093-2	S2U	UN	110		fatal	truck	yes	yes																
R095-1	U2U	U	100		admit	car	yes	yes			no													
R096-1	S2U	FN	80		treat	pvan	yes	yes			yes	yes	86	58	59	62	64	68	73	74	76	80	83	69.7
R096-2	S2U	FN	80		treat	car	accel	yes																
R098-1	U2U	U	100		fatal	car	yes	yes			no													
R099-1	S2U	FN	100		admit	car	yes	yes			yes	yes	111	77	77	79	88	90	93	94	95	95	96	88.4
R099-2	S2U	FN	100		admit	4wd	turn	yes																
R100-1	S2U	FN	100		fatal	car	yes	yes			yes	yes	80	67	70	82	86	86	88	92	92	103	105	87.1
R100-2	S2U	FN	100		fatal	truck	yes	yes		gway														
R102-1	S2U	FF	80		admit	car	yes	yes			yes	yes	143	72	73	77	77	78	79	83	84	87	93	80.3
R102-2	S2U	FF	80		admit	car	yes	yes			yes	yes	85	69	74	75	77	78	78	82	82	88	89	79.2
R103-1	S2U	UN	110		treat	car	overtak	yes																
R103-2	S2U	UN	110		treat	truck	yes	yes																
R104-1	S2U	UNN	110		fatal	car	overtak	yes																
R104-2	S2U	UNN	110		fatal	car	follow	yes																
R104-3	S2U	UNN	110		fatal	sw	yes	yes				no												
R106-1	S2U	U	100		fatal	car	yes	yes			no													
R107-1	SMU	UN	100		admit	panel	yes	yes	sleep			no												
R107-2	SMU	UN	100		admit	car	yes	yes				no												
R108-1	SMD	F	110		admit	4wd	yes	yes			yes	yes	111	96	98	103	107	107	107	108	112	122	124	108.4
R109-1	SMD	UN	110		fatal	semi	yes	yes																
R109-2	SMD	UN	110		fatal	car	turn	yes																
R112-1	S2U	N	100		treat	car	overtak	yes																
R114-1	S2U	UU	100	35	treat	car	yes	yes				no												
R114-2	S2U	UU	100	35	treat	car	yes	yes				no												
R115-1	S2U	U	100		treat	car	yes	yes				no												
R118-1	S2U	FN	80		admit	car	yes	yes			yes	yes	74	57	58	64	66	67	72	74	76	77	79	69.0
R118-2	S2U	FN	80		admit	car	turn	yes																
R119-1	U2U	U	100		admit	car	yes	yes			no													
R122-1	S2U	N	80		treat	car	yes	yes	sleep															
R123-1	S2U	FF	100		treat	4wd	yes	yes			yes	yes	69	41	45	46	46	49	51	58	58	61	68	52.3
R123-2	S2U	FF	100		treat	ute	yes	yes			yes	yes	75	40	44	44	48	48	48	54	55	58	61	50.0
R124-1	SMD	FN	110		fatal	sw	yes	yes			yes	yes	123	88	98	99	99	100	102	104	105	106	110	101.1
R124-2	SMD	FN	110		fatal	car	turn	yes																
R125-1	U2U	U	100		admit	car	yes	yes				no												
R129-1	S2U	FN	100		treat	4wd	yes	yes			yes	yes	86	71	72	78	79	80	83	83	84	90	98	81.8
R129-2	S2U	FN	100		treat	panel	yes	yes		gway														
R132-1	S2U	UN	80		fatal	car	overtak	yes																
R132-2	S2U	UN	80		fatal	semi	yes	yes																
R135-1	S2U	F	100		admit	4wd	yes	yes			yes	yes	70	52	56	63	65	67	69	72	72	73	77	66.6
R136-1	S2U	UU	80		admit	car	yes	yes				no												
R136-2	S2U	UU	80		admit	car	yes	yes				no												
R137-1	S2U	F	100		fatal	sw	yes	yes			yes	yes	111	80	86	90	92	95	106	107	111	111	144	102.2
R138-1	S2U	N	100	25	treat	car	yes	yes	blackout															
R140-1	S2U	UN	80		treat	truck	yes	yes																
R140-2	S2U	UN	80		treat	car	turn	yes																
R141-1	S2U	FU	100		treat	ute	yes	yes				no												
R141-2	S2U	FU	100		treat	car	yes	yes			yes	yes	63	57	61	63	65	66	72	81	82	83	90	72.0
R142-1	S2U	NN	100		admit	bicycle	yes	yes																
R142-2	S2U	NN	100		admit	car	turn	yes																
R143-1	S2U	FN	100		treat	car	yes	yes			yes	yes	98	83	85	85	85	90	91	92	93	97	102	90.3
R143-2	S2U	FN	100		treat	car	turn	yes																
R148-1	S2U	N	110	85	fatal	car	yes	no																
R149-1	S2U	FUN	100		admit	car	yes	yes			yes	yes	112	65	71	75	81	83	84	84	91	91	104	82.9
R149-2	S2U	FUN	100		admit	car	yes	yes				no												
R149-3	S2U	FUN	100		admit	car	follow	yes																
R150-1	S2U	UN	100		admit	truck	yes	yes																
R150-2	S2U	UN	100		admit	car	turn	yes																
R151-1	S2U	F	80	55	treat	car	yes	yes			yes	yes	85	55	56	57	59	59	60	62	62	69	69	60.8
R152-1	S2U	UN	80		treat	car	yes	yes				no												
R152-2	S2U	UN	80		treat	car	turn	yes																
R153-1	SMD	U	100		treat	car	yes	yes				no												
R155-1	U2U	N	100		fatal	car	yes	yes	suicide															
R158-1	S2U	FN	100		treat	car	yes	yes			yes	yes	126	77	86	88	88	89	92	95	96	102	109	92.2
R158-2	S2U	FN	100		treat	car	turn	yes																
R161-1	S2U	UN	80	55	fatal	car	overtak	yes																
R161-2	S2U	UN	80	55	fatal	mc	yes	yes																
R162-1	S2U	U	100		admit	car	yes	yes				no												
R163-1	SMD	U	110		admit	car	yes	yes				no												
R164-1	S2U	F	100	55	fatal	car	yes	yes			yes	yes	94	72	72	76	77	77	80	81	85	92	92	80.4
R165-1	S2U	NN	110		treat	ute	slow	yes																
R165-2	S2U	NN	110		treat	semi	slow	yes																
R166-1	S2U	FN	100		treat	sw	yes	yes			yes	yes	116	90	91	93	94	95	98	98	99	100	105	96.3
R166-2	S2U	FN	100		treat	car	turn	yes																
R167-1	SMD	NN	110		treat	car	follow	yes																
R167-2	SMD	NN	110		treat	car	turn	yes																
R168-1	S2U	N	100	80	fatal	car	yes	no																
R169-1	S2U	NN	110		treat	car	slow	yes																
R169-2	S2U	NN	110		treat	semi	turn	yes																
R170-1	S2U	FN	100		treat	car	yes	yes			yes	yes	93	72	76	78	79	81	82	83	83	87	103	82.4
R170-2	S2U	FN	100		treat	ute	turn	yes																
R172-1	S2U	F	100		treat	car	yes	yes			yes	yes	83	67	69	76	79	82	90	92	96	99	100	85.0
R173-1	S2U	N	80		treat	sw	yes	no																
R174-1	S2U	FU	100		admit	car	yes	yes			yes	yes	108	84	95	95	97	98	99	100	102	103	109	98.2
R174-2	S2U	FU	100		admit	car	yes	yes				no												
R178-1	S2U	FN	80		treat	car	yes	yes			yes	yes	56	52	57	57	57	60	63	66	78	80	90	66.0
R178-2	S2U	FN	80		treat	car	turn	yes																
R180-1	S2U	UU	100		treat	car	yes	yes				no												
R180-2	S2U	UU	100		treat	car	yes	yes				no												
R181-1	S2U	F	80	65	treat	car	yes	yes			yes	yes	60	54	55	57	59	60	61	66	66	69	71	61.8
R182-1	S2U	UN	100		fatal	mc	yes	yes																
R182-2	S2U	UN	100		fatal	4wd	turn	yes																
R183-1	S2U	FF	100	75	admit	car	yes	yes			yes	yes	96	73	73	74	75	78	83	87	89	91	99	82.2
R183-2	S2U	FF	100	75	admit	car	yes	yes			yes	yes	83	82	83	88	88	90	92	95	96	100	111	92.5
R184-1	S2U	UN	100		treat	car	overtak	yes																
R184-2	S2U	UN	100		treat	truck	yes	yes																

Case	Road	Type	Limit	Adv	Severity	Unit	Free	Sober	Medical	Illegal	Cont	Recon	Speed	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	ConAve
R186-1	S2U	U	110		admit	car	yes	yes				no												
R187-1	SMD	UN	90		fatal	car	turn	yes																
R187-2	SMD	UN	90		fatal	semi	yes	yes																
R188-1	S2U	UN	100		fatal	sw	yes	yes			no													
R188-2	S2U	UN	100		fatal	ute	yes	no																
R189-1	S2U	F	100	85	admit	4wd	yes	yes			yes	yes	90	70	71	75	79	82	85	86	86	96	100	83.0
R190-1	S2U	F	110		treat	car	yes	yes			yes	yes	81	93	97	99	103	105	106	109	109	110	123	105.4
R192-1	S2U	FN	100		treat	car	yes	yes			yes	yes	112	92	92	92	97	98	101	102	104	105	108	99.1
R192-2	S2U	FN	100		treat	car	turn	yes																
R193-1	S2U	F	110		fatal	car	yes	yes			yes	yes	148	75	81	97	99	105	108	110	111	116	125	102.7
R194-1	SMD	UN	110		fatal	semi	yes	yes																
R194-2	SMD	UN	110		fatal	car	turn	yes																
R195-1	S2U	UU	80	45	fatal	ute	yes	yes				no												
R195-2	S2U	UU	80	45	fatal	mc	yes	yes																
R199-1	S2U	UU	100	35	admit	car	yes	yes				no												
R199-2	S2U	UU	100	35	admit	truck	yes	yes																
R200-1	S2U	FU	100		admit	car	yes	yes			yes	yes	86	59	62	65	66	66	68	71	71	71	75	67.4
R200-2	S2U	FU	100		admit	mc	yes	yes																
R201-1	S2U	FN	110		treat	car	yes	yes			yes	yes	110	92	92	92	97	98	101	102	104	105	108	99.1
R201-2	S2U	FN	110		treat	ute	turn	yes																
R202-1	S2U	F	110	75	admit	car	yes	yes			yes	yes	122	55	63	64	66	71	74	80	85	89	102	74.9
R203-1	S2U	UN	90		treat	mc	yes	yes																
R203-2	S2U	UN	90		treat	car	turn	yes																
R205-1	U2U	U	100		admit	car	yes	yes			no													
R207-1	S2U	FN	110		admit	sw	yes	yes			yes	yes	70	60	72	76	77	81	81	82	85	87	89	79.0
R207-2	S2U	FN	110		admit	car	yes	yes		gway														
R209-1	S2U	U	100	55	fatal	mc	yes	yes																
R210-1	S2U	FN	100		admit	car	yes	yes			yes	yes	112	65	65	66	73	78	79	82	85	89	92	77.4
R210-2	S2U	FN	100		admit	ute	yes	yes		gway														
R212-1	SMD	FN	110		admit	car	yes	yes			yes	yes	111	81	92	95	105	107	108	111	114	115	120	104.8
R212-2	SMD	FN	110		admit	car	turn	yes																
R213-1	S2U	F	100		admit	car	yes	yes			yes	yes	114	81	101	103	105	107	113	116	116	121	129	109.2
R214-1	S2U	F	100		treat	car	yes	yes			yes	yes	84	66	75	78	78	80	81	82	84	89	94	80.7
R216-1	SMD	FN	80		fatal	car	yes	yes			yes	yes	71	59	69	69	71	75	79	79	80	80	84	74.5
R216-2	SMD	FN	80		fatal	car	turn	yes																
R217-1	S2U	U	80		admit	mc	yes	yes																
R218-1	S2U	FN	80		treat	car	yes	yes			yes	yes	83	53	56	63	64	66	69	71	71	76	79	66.8
R218-2	S2U	FN	80		treat	4wd	turn	yes																
R219-1	S2U	FF	80		admit	pvan	yes	yes			yes	yes	74	61	62	64	65	67	67	69	70	73	73	67.1
R219-2	S2U	FF	80		admit	car	yes	yes			yes	yes	77	63	63	63	64	65	66	67	67	73	74	66.5
R221-1	S2U	U	100		fatal	car	yes	yes				no												
R222-1	S2U	UN	100		admit	mc	yes	yes																
R222-2	S2U	UN	100		admit	4wd	uturn	yes																
R224-1	SMD	N	110		fatal	car	yes	yes	pain															
R225-1	SMD	U	80		fatal	4wd	yes	yes			no													
R227-1	S2U	N	110	75	fatal	car	yes	no																
R229-1	S2U	N	110		fatal	4wd	overtak	yes																
R231-1	S2U	FF	100	45	admit	sw	yes	yes			yes	yes	57	45	46	47	47	48	50	50	51	51	52	48.7
R231-2	S2U	FF	100	45	admit	car	yes	yes			yes	yes	54	39	43	47	48	48	50	51	52	55	56	48.9
R232-1	S2U	FN	100		admit	sw	yes	yes			yes	yes	114	68	83	84	85	87	88	93	96	97	100	88.1
R232-2	S2U	FN	100		admit	car	yes	yes		gway														
R233-1	S2U	UN	100		fatal	car	yes	yes				no												
R233-2	S2U	UN	100		fatal	tractor	yes	yes																
R234-1	SMD	UN	90		treat	semi	yes	yes																
R234-2	SMD	UN	90		treat	semi	turn	yes																
R236-1	S2U	N	80		fatal	ute	yes	no																
R237-1	S2U	FF	80		admit	4wd	yes	yes			yes	yes	61	47	48	54	55	55	56	57	57	60	68	55.7
R237-2	S2U	FF	80		admit	4wd	yes	yes			yes	yes	54	48	50	51	52	54	55	56	57	57	62	54.2
R238-1	S2U	F	100	85	admit	car	yes	yes			yes	yes	96	79	84	87	88	91	97	97	99	100	101	92.3
R239-1	S2U	FN	100		admit	panel	yes	yes			yes	yes	113	57	60	61	61	62	66	67	69	69	77	64.9
R239-2	S2U	FN	100		admit	car	accel	yes																
R240-1	SMU	FN	100		treat	4wd	yes	yes			yes	yes	117	75	80	80	80	83	84	86	87	91	95	84.1
R240-2	SMU	FN	100		treat	car	turn	yes																
R241-1	SMD	NN	110		admit	car	slow	yes																
R241-2	SMD	NN	110		admit	car	turn	yes																