Rural Speed and Crash Risk

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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, rural, crash risk, case control study

INTRODUCTION

Although it is clear that high speed increases the risk of being involved in a road crash only three previous studies have attempted to quantify the actual relationship in rural areas (1, 2, 3). All three studies reported that the crash risk curve was U shaped with crash risk being elevated at both low and high speeds. Serious concerns have been raised about the methodology used in these studies and the interpretation of the results.

The Road Accident Research Unit attempted to address these concerns in a study examining 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 (4). The study also attempted to ascertain the possible effect of hypothetical reductions in free travelling speeds on the frequency of rural casualty crashes.

METHOD

In order to estimate the relationship between free travelling speed and the relative risk of crash involvement in a rural area, a series of crashes was examined in detail to form the basis of a case control study. The 83 case vehicles were passenger vehicles involved in casualty crashes in 80 km/h or greater speed limit zones in rural areas within 100 km of Adelaide, South Australia. They were investigated at the scene by the Road Accident Research Unit and reconstructed using the latest computer aided crash reconstruction techniques.

The case vehicles had a free travelling speed prior to the crash. A free travelling speed was defined as the speed of a vehicle moving along a mid-block section of road, or with right of way through an intersection, and not slowing to leave, or accelerating into, a traffic stream. 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. The drivers of case vehicles were also required to have a zero measured BAC to exclude the effects of alcohol on the risk of crashing.

The 830 control vehicles (10 per case) were passenger vehicles 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 meter. The control vehicles were also required to have a free travelling speed as defined above.

Of the 259 crashes attended, 76 crashes and 83 case vehicles met the study criteria. The reasons for the exclusion of the other cases are listed in the main report on the study (4).

Due to the widely varying road conditions in the rural road crashes investigated, and speed limits ranging from 80 to 110 km/h, it was not logical to calculate the relative risks based on absolute free travelling speeds since the fundamental speed distributions were very different on different sections of road. It was therefore decided to normalise all case and control speeds to the average of the control speeds at the sites of each of the crashes. This leads to the calculation of the relative risk of being involved in a casualty crash when travelling at a speed that is different from the average speed of non-crash involved vehicles relative to travelling at that average speed. Logistic regression modelling was used to establish the shape of the risk curve.

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

RESULTS

Relative Risk Curve

Modified logistic regression modelling was used to establish the shape of the casualty crash relative risk curve from the distributions of free travelling speeds for the case and control vehicles. 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.

The data were fitted using a range of logistic regression models and a quadratic model was found to provide a good fit for speed differences between the cases and the average of the controls from –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.

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 involvement in a casualty crash 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 1 together with the 95 per cent confidence intervals calculated using simulation.

Table 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*	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

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 1. 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 1, 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 at least 20 km/h slower.

Hypothetical Scenarios

Hypothetical speed reduction scenarios were undertaken where the equation for the relative risk curve was used to calculate the expected reduction in risk for each of the 259 crashes investigated under a number of reduced free travelling speed hypothetical scenarios. Since the process is quite complex the reader is referred to the full report for details (4). The results of the hypothetical calculations are presented in Table 2.

Table 2
Percentage of Rural Casualty Crashes
Eliminated by Hypothetical Reductions in Free Travelling Speeds
South Australia

Hypothetical Situation	**% Reduction in number of Crashes**
5 km/h free travelling speed reduction	30.5
10 km/h free travelling speed reduction	46.5
No speeds above control average	41.0
Total compliance with speed limits	23.8
80 km/h maximum speed limit on undivided roads with compliance as at present	33.4
100 km/h maximum speed limit on all roads with compliance as at present	8.0

It can be seen in Table 2 that these hypothetical scenarios indicate that a large proportion of the 259 rural out of town casualty crashes attended in this study would have been avoided (or have been reduced to non-casualty crashes) 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 have led to a 31 per cent reduction.

It was also found that 41 per cent of all the casualty crashes investigated would have been avoided if none of the vehicles had been travelling above the average speed of the control vehicles.

Total compliance with posted speed limits would have led to a 24 per cent reduction in these casualty crashes.

Lowering the maximum speed limit on undivided roads to 80 km/h and obtaining the same level of compliance as at present would have reduced the frequency of casualty crashes by 33 per cent overall and by 46 per cent on rural undivided roads with current speed limits above 80 km/h.

Although South Australia has a maximum unsigned open road speed limit of 100 km/h, there are a number of roads that are sign posted as 110 km/h. If the speed limit on all of these roads was lowered to 100 km/h and the level of compliance was as at present, the overall frequency of rural out of town casualty crashes would have been reduced by 9 per cent and the frequency on 110 km/h zoned roads would have been reduced by 29 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. Therefore a strong case can be made for the strict enforcement of speed limits.

No evidence was found for a U shaped risk curve whereby lower travelling speeds are associated with an increased risk of being involved in a casualty crash. This suggests that the previous studies showing such a relationship may have done so as a result of methodological deficiencies. Absolute travelling speeds are much more important than speed variances as a determinant of the risk of involvement in a casualty crash.

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 as could reducing current 110 km/h zones to 100 km/h.

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 enforcement of speed limits, similar to that which has developed in relation to blood alcohol limits during recent decades.

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REFERENCES

1. Solomon D. Accidents on main rural highways related to speed, driver and vehicle. Washington, DC: US Department of Commerce & Bureau of Public Roads. 1964.

2. Cirillo JA. Interstate system accident research: study II, interim report II. Public Roads 1968; 35(3): 71-75. 1968.

3. Research Triangle Institute. Speed and accidents: Volume I. Washington, DC: US Department of Transportation. 1970.

4. Kloeden CN, Ponte G, McLean AJ. Travelling speed and the risk of crash involvement on rural roads. Australian Transport Safety Bureau. CR 204. Canberra, Australia. 2001. (http://raru.adelaide.edu.au).