DOES THE CRASH RATE REALLY DOUBLE FOR EACH 5 KM/H ABOVE 60 KM/H

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ABSTRACT

The *"Travelling Speed and Risk of Crash Involvement"* research report of November 1997 found that *"the risk of involvement in a casualty crash doubled with each 5 km/h increase in free travelling speed above 60 km/h."* This report was undertaken by an excellent team, but the findings were was at apparent odds with previous research which showed a crash rates increasing for speeds above and below speeds in excess of the speed limit. This paper reviews the data in this report in a different manner, and other factors, to give a different view of what the information can be shown to prove. It concludes that the data supports that risk of crashes is best represented by a U shaped curve around mean speeds, with crash risk rising for very low speeds, and for high speeds. It further suggest that the current speed enforcement tolerances are probably appropriate, but that the penalties at 15 km/h or more above the speed limit should be more severe.

INTRODUCTION

The *"Travelling Speed and Risk of Crash Involvement"* research report of November 1997 is an excellent example of thorough road safety research. It was carried out by the NHMRC Road Accident Research Unit of the University of Adelaide on behalf of the Federal Office of Road Safety (now the Australian Transport Safety Bureau). The authors were CN Kloeden, AJ (Jack) McLean, VM Moore and G Ponte. In addition to the excellence of the work, the *"Travelling Speed and Risk of Crash Involvement"* report was presented in a way that allowed others to thoroughly review and re-analyse the data if required. The report found that *"in a 60 km/h speed limit area, the risk of involvement in a casualty crash doubled with each 5 km/h increase in free travelling speed above 60 km/h."*

Literature review

This literature review covered studies which have been undertaken to quantify the relationship between travelling speed and the risk of crash involvement.

The review was extensive and included studies by Tilden, 1936, DeSilva, 1940; Lefeve, 1956; Cleveland, 1959, Greenshields, 1963; Solomon (1964), Taylor (1965), Munden (1967), Cirillo (1968), Research Triangle Institute (1970), White and Nelson (1970), Johns and Bundy (1974), Joksch (1975), Krzeminski (1976), O'Day and Flora (1982), Wilson and Greensmith (1983), the Transportation Research Board (1984), Wasielewski (1984), Lave (1985), Hillman and Plowden (1986, cited in Finch, et al., 1994), Fieldwick and Brown (1987), Garber and Gadirau (1988), Godwin and Kulash (1988), Fildes, Rumbold and Leening, 1991, The Insurance Institute for Highway Safety (1991), Sliogeris (1992), Godwin (1992), Cameron, Cavallo and Gilbert (1992), West, et al. (1993), Finch, et al. (1994), Baruya and Finch (1994), Lave and Elias (1994), Winnett (1994), Moore, Dolinis and Woodward (1995), Fridstrom, et al. (1995), Stuster (1995), Brindle (1996), Graham (1996), and Schmidt (1996),

In its summary of the literature review it reported that evidence from correlational studies suggests there is a positive association between speed and crash involvement. It referenced three studies conducted in the United States more than 25 years ago that concluded that crash involvement was a U-shaped function of vehicle travelling speed. The report found these studies were subject to methodological problems, with the consequence that the meaning of the results was not certain. In particular, it found it was debatable as to whether the elevated involvement rates found at low speeds were supportable. Other studies which have linked drivers' speeds and accident histories have, on the whole, not supported a U-shaped relationship. A recent Australian study found that the slowest drivers had the least experience of crashes, while the fastest drivers had the greatest experience of crashes.

Research methodology

The researchers attended 952 crashes, and selected case vehicles used the following criteria:

> Crash was in the Adelaide metropolitan area; Road was 60 km/h speed limit zone; Not on a section of road with an advisory speed sign of less than 60 km/h; Case vehicle was a car or car derivative (eg station wagon or utility); At least one person was transported from the crash scene by ambulance; Case vehicle had a free travelling speed prior to the crash; Case vehicle not executing an illegal manoeuvre prior to the start of the

crash sequence; Case vehicle driver did not suffer from a medical condition that caused the crash; Case vehicle driver had a zero blood alcohol concentration (BAC); Sufficient information was available to carry out a computer-aided crash reconstruction; Case vehicle did not roll over; Crash did not occur while it was raining

Out of the 952 crashes, 148 were selected as satisfying the criteria for at least one vehicle, and a total of 151 case vehicles were identified. The major reasons for omitting crashes were no one was transported from the crash in an ambulance (325 cases); case vehicle not a car or car derivative (148 cases); case vehicle did not have a free travelling speed (148 cases); case vehicle doing an illegal manouevre (26 cases); crash due to medical condition of the driver (23 cases); and site not a 60 km/h zone (18 cases)

And the following criteria were used in the selection of four control vehicles to match each case vehicle:

Same location, weather conditions, day of week, and time of day as the crash; Same direction of travel as the case vehicle; Car or car derivative; Free travelling speed

The speed profile of the case vehicles as a group was then compared to the speed profile of the control vehicles as a group to determine relative risks of crashes. These are summarised in Table 4.3 from the report below.

In Table 4.3 the relative risk is determined by relating the ratio of cases and controls at 60 km/h (that is 29/205), to the ratio of cases and controls at other speeds. The implied hypothesis is that if speed was not a factor, then the distributions of speeds for cases and controls would be similar

Table 4.3 - Travelling Speed and the Risk of Involvement in a Casualty Crash Relative to Travelling at 60 km/h in a 60 km/h Speed Limit Zone

Nominal Speed	Speed Range	No. of Cases	No. of Controls	Relative Risk	Lower Limit*	Upper Limit*
35	33-37	0	4	0	-	-
40	38-42	1	5	1.41	0.16	12.53
45	43-47	4	30	0.94	0.31	2.87
50	48-52	5	57	0.62	0.23	1.67
55	53-57	19	133	1.01	0.54	1.87
60	58-62	29	205	1.00	1.00	1.00
65	63-67	36	127	2.00	1.17	3.43
70	68-72	20	34	4.16	2.12	8.17
75	73-77	9	6	10.60	3.52	31.98
80	78-82	9	2	31.81	6.55	154.56
85	83-87	8	1	56.55	6.82	468.77
	88+	11	0	infinite		
Total		**151**	**604**			

- 95% confidence limits of the estimated relative risk

Crash reduction from reduced travelling speeds

Finally the study estimated the likely outcomes from five hypothetical scenarios:

1. All case vehicles were assumed to have a travelling speed of 5 km/h less than their calculated travelling speed.
2. All case vehicles were assumed to have a travelling speed of 10 km/h less than their calculated travelling speed.
3. All vehicles that were calculated as travelling over 60 km/h were assumed to be travelling 10 km/h slower; all vehicles calculated as travelling between 50 and 60 km/h were assumed to be travelling at 50 km/h; and all vehicles calculated as travelling under 50 km/h did not have their speeds changed. This scenario was intended as a first approximation estimate of the effect of a change in speed limit from 60 to 50 km/h.
4. The same as 3 except that the reductions were only applied to crashes occurring on a local street; crashes on main roads did not have their speeds altered. This scenario was intended as a first approximation estimate of the effect of a change in speed limit from 60 to 50 km/h on local streets only.
5. All case vehicles with a calculated travelling speed above 60 km/h were assumed to be travelling at 60 km/h.

The results were presented in Table 4.7 in the report which is reproduced below:

Table 4.7 Hypothetical Outcomes at Reduced Travelling Speeds

Hypothetical Situation	**% Reduction in number of Crashes**	**% Reduction in number of Persons Injured** Note 1	**% Reduction in average Delta V** Note 2	**% Reduction in average Crash Energy** Note 2
10 km/h speed reduction	41.5	34.6	25.5	38.7
5 km/h speed reduction	15.0	13.1	16.1	23.6
Limit 60 km/h with total compliance	28.6	30.4	11.8	21.7
Limit 50 km/h with compliance as at present	32.7	26.6	24.9	37.5
Limit 50 km/h on local streets only with compliance as at present	6.1	4.2	2.8	4.7

1 Reductions due solely to the crash not happening under the scenario.
2 Average reduction for persons injured in crashes that would still have happened under the scenario.

An alternate method was also used based on Table 4.3. This assumed that the ratio of case vehicles to control vehicles would be the same at high speeds as the ratio at 60 km/h. This analysis resulted in the following Table:

Table 4.8 - The effect of eliminating speeding on free travelling speed Casualty Crashes

Nominal Speed	**Speed Range**	**No. of Cases**	**Relative Risk**	**Expected cases –** Note 1	**% reduction in crashes**
35	33-37	0	0	0	0
40	38-42	1	1.41	1	0
45	43-47	4	0.94	4	0
50	48-52	5	0.62	5	0
55	53-57	19	1.01	19	0
60	58-62	29	1.00	29	0
65	63-67	36	2.00	18	50.0
70	68-72	20	4.16	4.8	76.0
75	73-77	9	10.60	0.8	90.6
80	78-82	9	31.81	0.3	96.9
85	83-87	8	56.55	0.1	98.2
	88+	11	infinite	0.0	100.0
Total		**151**		**82.0**	**45.6**

Note 1: Assuming all relative risks reduced to 1.00 above 60 km/h

RATIONALE FOR THIS REPORT

The author had undertaken considerable work in respect of speed and crashes and speed monitoring while Manager of Road safety Research at VicRoads and had concerns about the concept of an absolute relationship with speed and crashes. These concerns were heightened when Victoria's TAC used the concept in it's advertising campaign. Concerns were underpinned by a hypothesis of the mechanisms that lead to vehicles travelling at observed speeds.

Hypothesis as to mechanisms that determine vehicle speed

The speed of a vehicle at a particular point in the road network, and at a particular time is determined by:

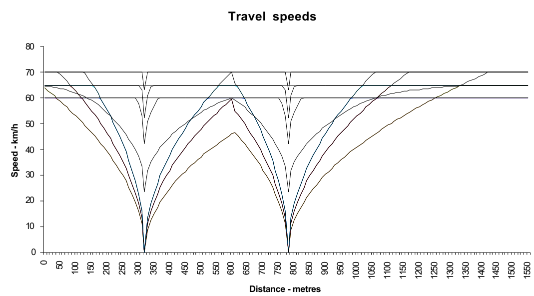
Vehicle factors: The ability of the vehicle to accelerate from rest or from a low speed situation; The ability of a vehicle to maintain speed up a grade; The ability of a vehicle to brake; The stability of the vehicle at a turn or corner; The accuracy of the vehicle speedometer; The ability of the vehicle to handle road roughness; The effect on vehicle performance of a trailer or caravan, and of any load.

Road factors: Road surface – sealed or unsealed; Road roughness – smooth, corrugated, potholed; Road horizontal geometry – radii of curves; Road vertical geometry – camber, superelevation, etc; Road type – two lane single carriage way, divided road, freeway; and Sight distance.

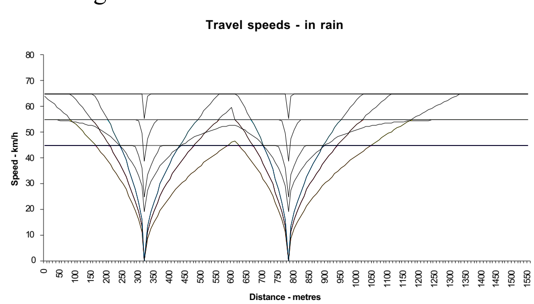
Environmental factors: The ambient light level – bright sunshine, overcast/ dull, night; Whether the road is wet or dry; Whether rain or drizzle is present, and how heavy that rain or drizzle is; Whether mist or fog is present, and how thick that mist of fog is; The likelihood of black ice or the presence of snow; The presence of water lying on the road, including floods; and Other effects like mirages in hot weather..

Driver factors: The speed at which a driver feels comfortable, including familiarity with the road and response to vehicle, road and environmental factors; the perception of the range of likely behaviour of other drivers; The preferred levels of acceleration and/or braking; The attitude of the driver to speeding; The driver's perception of enforcement levels; The driver's perception of the effects of penalties on their lifestyle; and The driver's level of skills, experience, and self-confidence.
Legislation/ regulation and related factors: The prevailing speed limit; The presence of an enforcement tolerance; The presence of advisory signs; and Other speed related requirements including the required speeds passing trams or buses, etc
Other factors: The percentage of large, heavy and/or slow vehicles in the traffic stream; and The level of congestion, and whether the congestion consists of regular drivers (commuters) or non-regular drivers (people setting out on holidays or social trips);

A simple example is modelled below for a 1500 metre length of road with two signalized intersections. The traffic flow consists of drivers with preferred speeds of 60, 65, and 70 km/h, with differing preferred acceleration and deceleration rates. Some drivers slow on the green light while others drive straight through. The heavy line represents the average speed of the group.



In the range from 100 metres to 1200 metres, speeds are highly variable and the average speed is low. Whereas at 1500 metres the average is high and variability is low because all vehicles have reached their preferred speeds. At the same site, the effect of rain may be as shown below, with speeds generally lowered, and the most cautious drivers decreasing their speeds by the greatest margin.



Hence while the prevailing speed limit may be the same, average speeds and speed variability across the network will vary both in distance and in time. And effectively the average speeds and speed variability will be determined by the collective actions of a large number of drivers.

VicRoads Speed Monitoring Project
In the period from the late 1980'2 to early 1990's, VicRoads carried out a major project monitoring speeds at sites where vehicles were likely to have reached preferred speeds. The project was aimed at determining the effects of speed cameras on speeding behaviour.

For 60 km/h zones, average speeds were in the 65-67 km/h range, while in 100 km/h zones they were in the range 100-103 km/h. The closer observance of 100 km/h speed limits was considered to have arisen from two factors: the presence of speed limited and/oe slow heavy vehicles, and the fact that at 100 km/h speedometers typically read high by around 4 km/h. these observations support some of the mechanisms that control speeding.

During the project there were two cases of speed zones being altered from 75 km/h to 60 km/h:

1. In the first case, the alteration was made in error by a young officer, and did not comply with speed limit guidelines –**No measurable change in speed behaviour was observed!** and
2. In the second, the limit was altered due to the urban development at the fringe of a locality on Melbourne's outskirts. The compliance with the new 60 km/h limit was very high.

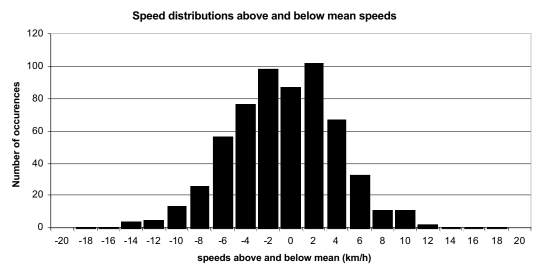
These observations support the view that compliance with speed limits is a multi-factor mechanism, and that driver's assess risks and appropriateness of speed limits in setting their own speeds.

METHOD

The method taking in reviewing this paper was to consider the literature review and then based on the hypothesis for speed behaviour re-analyse the data.

Literature review

There appeared to be a predisposition to querying the U shaped risk curve about the mean speed. Given that drivers operate their vehicles within a normally expected range of behaviors of other drivers and road users, it makes logical sense that vehicles travelling much slower or faster than expected would be likely to create problems. The predisposition may have been assisted by a lack of appreciation of the narrowness of the speed distributions likely to be experienced. The graph below shows speed distributions of control vehicles above and below the mean speed.

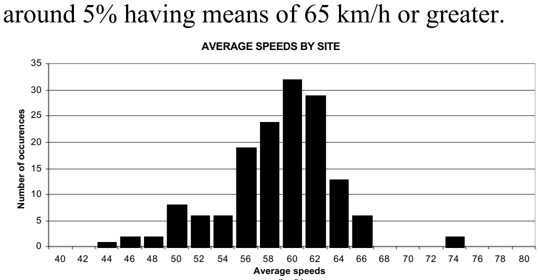


Analysis of the data shows that the 15th percentile/ 85th percentiles are –5 km/h and +5km/h, and the 2%/98% figures are –10 km/h and +10 km/h. In the Solomon (1964), Research triangle Institute (1970) and Fildes, Rumbold and Leening (1991) context this is a very narrow band about the mean.

Hence while the Solomon (1964) risk curves for very slow vehicles may be questioned, it is less valid to discard the U shaped risk curve altogether.

Re-analysis of data

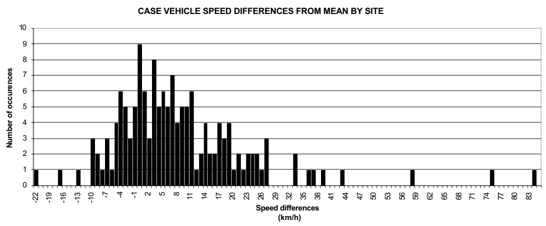
An initial check was made of the consistency of data be researching the range of site mean speeds.The range of mean speeds of controls was founsd to be from 43 – 74 km/h, with around 20% having means of 55 km/h or less and around 5% having means of 65 km/h or greater.



The range of mean speeds was regarded as reflecting a lack of consistency between sites, and so analysis was undertaken relating speeds and crashes to speed differentials at each site.

RESULTS

Analysis of the data showed the graph below of the spread of case vehicle speeds against site mean speeds.



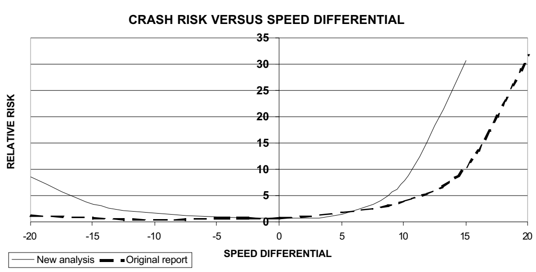
The range was from –22 km/h to plus 84.5 km/h, with data skewed towards higher speeds.

Further analysis produced the risk curve data below.

Table - Speed differential and the Risk of Involvement in a Casualty Crash Relative to Travelling at the mean speed

Speed differential	Speed Range	No. of Cases	No. of Controls	Relative Risk
-20	-22 to 18	1	1	8.81
-15	-17 to -13	2	5	3.52
-10	-12 to -8	6	30	1.76
-5	-7 to -3	19	149	1.12
0	-2 to 2	26	229	1.00
5	3 to 7	31	159	1.71
10	8 to 12	21	23	8.04
15	13 to 17	14	4	30.83
20	18 to 22	11		infinite
25	23 to 27	10		infinite
	28 +	9		infinite
Total		**150**	**600**	

The results are graphed below and compared to the form of the original reports data by setting 0 = 60 km/h.



CONCLUSIONS

Re-analysis of the original data shows that:

- Driver selection of travel speed is based on many factors, with the prevailing speed limit and speed enforcement being only two of these factors;
- In a 60 km/h limit zone, average free speeds on dry days during daylight hours exhibit significant variability;
- A more consistent approach to the data is to use speed differentials from the mean speed, and that approach produces a U shaped risk curve.

VicRoads speed monitoring data reveals that on those sections of roads where speed enforcement is most likely to occur, mean speeds are likely to be high, and in the range of 65 – 67 km/h. Given this fact and the risk curve above, the use of a 10 km/h enforcement tolerance, and the setting of 15 km/h as the next level of enforcement represent a fair approach to speed enforcement.

However the author agrees with the finding of the original report that the penalties at 15 km/h or higher above the speed limit should be increased based on the very rapid increase in crash risk.

ACKNOWLEDGEMENTS

The excellent work undertaken by CN Kloeden, AJ (Jack) McLean, VM Moore and G Ponte in producing the excellent research report on which this work is based is acknowledged

REFERENCE

"Travelling Speed and Risk of Crash Involvement" research report, November 1997, by -NHMRC Road Accident Research Unit of the University of Adelaide on behalf of the Federal Office of Road Safety, CN Kloeden, AJ (Jack) McLean, VM Moore and G Ponte.