Changes to speed limits and crash outcome – Great Western Highway case study

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Abstract

Numerous studies, across many countries, have evaluated the outcomes of changes in prevailing speed limits. Fatalities and injuries have fallen when speed limits have been lowered and have increased when speed limits have been raised. Models of speed changes allow a prediction of the safety benefits of a speed limit reduction. This paper studies the relationship between changes in the posted speed limits and crash history for a section of the Great Western Highway in rural NSW, where the speed limit was reduced from 110 km/h to 100 km/h. This study showed that travel speeds are reduced following a speed limit reduction, with clear safety benefits (26.7% reduction in casualty crashes) consistent with power model. Use of modelling in crash prediction depends, however, on a reasonably accurate estimate of the speed reduction expected.

Keywords

Speed Limit Reduction, Mean Speed, Crash History, Casualty Crashes, Power Model, Road Safety.

Introduction

Relationship between speed limits and road safety

There is a strong link between speed limits and road safety. Many studies world-wide have examined the effect of raising or lowering speed limits in both rural and urban environments and consistently show that crash incidence and injury severity decline whenever speed limits have been reduced and increase when speed limits are raised [1].

Nilsson [2] presented a power model of the relationship between speed and road safety. The power model stated that a given change in the mean speed of traffic is associated with a relative change in the number of crashes or casualties by means of a power function. Elvik [3,4] supported the power model and stated that speed has a major impact on the number of crashes and the severity of injuries and that the relationship between speed and road safety is causal, not just statistical. The exact relationship between speed and crashes is complex and depends on a wide range of specific factors. However, in general it can be said that the faster the speed, the greater the chance of a crash and the more severe the injuries in a crash.

Aims of this paper

The aim of this paper is to illustrate how recent research can be applied to assist decision-making about changes in speed limits to obtain safety benefits.

Issue

The Great Western Highway connects the regional cities of Lithgow (population about 12,000) and Bathurst (population about 32,000), about 140 km west of Sydney in New South Wales. The traffic volume (Annual Average Daily Traffic) is little over 10,000 and there is no evidence of large changes in traffic volume in last 10 years.

This section of the Great Western Highway had a 110 km/h speed limit for most of its length. The speed limit was reduced in February 2000 from 110 km/h to 100 km/h from 15.3 km from Lithgow to the outskirts of Bathurst, a total distance of 40 km. The reason for the speed limit change was that the 110 km/h speed limit was not consistent with the *NSW speed zoning guidelines* [5].

We looked at the crash data, for the four years before the speed limit change and for the four years after the speed limit change. For a 40 km section of non-urban road, it would rarely be worthwhile to use a count of fatal crashes to measure a change, therefore, we used casualty crashes, that is, all crashes in which anyone was killed or injured.

We compared the actual change in casualty crashes, for the four years before the speed limit change and for the four years following speed limit change, with the predicted change in casualty crashes based on research models.

Methodology

Nilsson's power model

Research on the relationship between speed and road safety has demonstrated that it is possible to predict the safety benefits of speed reductions, whether from changes to speed limit enforcement, or other actions to reduce speeds [6]. For non-urban roads, the model best supported by the research is Nilsson's power model [2,3]. It is called the power model because the model describes the relationship between speed and casualty crashes or casualties of different severities in terms of six power functions, all of which have the following form:

$$\frac{Crashes \quad After}{Crashes \quad Before} = \left(\frac{Speed \quad After}{Speed \quad Before} \right)^{Exponent} \qquad (1)$$

The power model's implications for given reductions in mean speed are:

- The reduction in casualty crashes is greater, proportionally, than the reduction in speed.
- The percentage reduction in fatal crashes is much larger than the percentage reduction in non-fatal injury crashes.
- Fatalities are reduced more than fatal crashes (if the mean number of fatalities per fatal crash is greater than one).

If speeds are reduced:

- Injuries are less severe on average.
- As well as casualty numbers being reduced, the proportion of casualties that are fatal is decreased.

Applying Nilsson's power model using a spreadsheet

For casualty crashes (for all severities together, including fatal), the equation 1 can presented as:

$$Y_1 = \left(\frac{V_1}{V_0} \right)^n Y_0 \qquad (2)$$

In equation 2, V denotes the mean speed changes: V_0 before to V_1 after. The other notation, Y, is the number of crashes: Y_0 before and Y_1 after. The power (exponent), *n*, to be used in the model depends on the road, particularly whether it is urban or non-urban, as well as the crash and casualty severity. Cameron and Elvik [4] estimated separate parameters for urban arterials, rural highways, residential roads, and freeways.

A spreadsheet model can be easily prepared to help assess proposed actions to reduce speeds (for example - a reduction in speed limit).

Estimating the ratio of the mean speed after to the mean speed before

Estimates based on Nilsson's power model (equation 2) require crash data (Y_0) to be entered, which is straightforward. The uncertain part is the mean speed reduction. Data on which to base mean speed reduction estimates have not always been readily available.

Elvik et al. [7] reviewed many studies of the relationship between change in speed and change in safety benefits. As part of the study, they also examined the relationship between change of speed limit and change of speed, using a linear regression [7, p93-94], which indicated that, on average, speeds were reduced by 25% of the reduction in the speed limit. They also reported great variation, among studies, in the effects on speeds of speed limit changes.

Findings

Actual reduction in casualty crashes

In the four years before the speed limit reduction, there were 45 casualty crashes on the relevant section of the Great Western Highway. In the four years after the reduction, there were 33 casualty crashes on the corresponding section.

That is, casualty crashes decreased by 26.7%, following the speed limit reduction.

Actual change in mean speed

An RTA speed survey conducted in 1999 towards the western end of the road section, showed a mean speed of 102.4 km/h, when the speed limit was 110 km/h. Further surveys in 2000 and 2001, after the speed limit change, at the same site, showed mean speeds of 97.9 and 97.5 km/h, respectively.

Reduction in casualty crashes predicted by power model

The exponent (n), for injury crashes estimated from the meta-analysis by Cameron and Elvik [4, Table 6], is 3.54 for a rural highway. Using equation 2, predicted number of casualty crashes (Y_1) would have been 38 casualty crashes.

This amounts to 16% reduction in casualty crashes, rather than the 26.7% reduction that was actually recorded.

Comparison

The safety outcome (26.7%) on the Great Western Highway was greater than what would have been predicted (16%) by the power model.

Based on mean speed surveys, the percentage of mean speed reduction (as a proportion of the speed limit reduction) was 50%, compared to power model's prediction of 25%.

Jurewicz [8, p12-13] undertook further analysis on the Elvik et al. [7] data, and reported that greater proportional reductions in mean speed were associated with higher speed limits. Jurewicz [8] went on to point out other studies where a greater reduction in mean speed was found, where there was greater speed limit compliance or where free-speeds were common. Jurewicz [8] also pointed out that small speed limit reduction, 10 km/h, resulted in a larger reduction in mean speed (as a proportion of the speed limit reduction). That is, as Elvik et al. [7] imply, and as reinforced by Jurewicz's [8] observations, the 25% of the speed limit reduction cannot be seen as a reliable guide to the reduction in mean speed to be expected.

One implication of the above discussion is that we would expect the reductions in mean speed to be a higher proportion of the speed limit reduction for rural high-speed locations, with a 10 km/h speed limit reduction, and good compliance.

Discussion

The Great Western Highway case is a limited test of the power model, for a number of reasons. It is a single location and effects of speed reduction from 110 km/h to 100 km/h are studied. In general, changes in speed have higher road safety benefits on high speed roads than on low speed roads.

An important point, in the context of this study, is that the initial mean speed can theoretically make a difference, because a reduction of 5 km/h in the mean speed can result in a slightly different ratio depending on the initial mean speed. However, the initial mean speed does not make a large difference to the estimate of benefits in a cost-benefit analysis. For example, if we erroneously took the initial mean speed to be 102 km/h, when it was actually 107 km/h, we would overestimate the benefits by only 5%. If the initial speed was actually 97 km/h, we would underestimate the benefits by only 5%. Therefore in practice the initial mean speed, in the context of this study, is very unlikely to make a difference to decision making based on a cost-benefit analysis, if the reduction in speed is accurate.

In NSW, surveys indicate that the mean free speed is often around the speed limit. In the higher speed zones, the mean speed is often less than the speed limit. In the 2009 surveys (prior to speed limit reduction), 20 of 21 sites in the speed surveys had a mean speed less than 110 km/h. For a given change in mean speed, an assumption that the initial mean speed was the speed limit will usually underestimate the benefits, but by a negligible proportion.

The estimate of the reduction in mean speed is important to the estimate of the benefits. If, in the example, the reduction in mean speed were 7.5 km/h, rather than 5 km/h, the benefits would be 45% higher. If the reduction were 2.5 km/h, the benefits would be 48% lower.

If the exponent used in the estimate were 10% lower, the benefits would be 9% lower. If it were 10% higher, the benefits would be 9% greater. Such small changes should not usually influence practical decision making.

Conclusion

It is clear from the study that speed limit reductions result in mean speed reductions, however, the effects of a given percentage change in mean speed vary according to the type of traffic environment.

The power model remains a valid model of the relationship between speed and road safety and it is possible to make useful predictions of the safety benefits to be expected from reductions in speed limits.

An important point, when estimating the benefits, is ability to accurately predict the mean speed reduction to be expected.

The study also confirms the latest research findings [8] that greater proportional reductions in mean speed are associated with higher speed limits.

From the point of view of road safety, the speed limit reduction on the Great Western Highway was successful as it led to a 26.7% reduction of casualty crashes.

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