Nilsson's Power Model connecting speed and road trauma: Does it apply on urban roads?

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Abstract
Nilsson (1) proposed power relationships connecting changes in traffic speeds with changes in road crashes at various levels of injury severity. Increases in fatal crashes are related to the 4th power of the increase in mean speed, increases in serious casualty crashes (those involving death or serious injury) according to the 3rd power, and increases in casualty crashes (those involving death or any injury) according to the 2nd power. Increases in numbers of crash victims at cumulative levels of injury severity are related to the crash increases plus higher powers predicting the number of victims per crash. These relationships were empirically derived based on speed changes resulting from a large number of rural speed limit changes in Sweden during 1967-1972. Nilsson (2) noted that there have been very few urban speed limit changes studied to test his power model. Elvik, Christensen and Amundsen (3) meta-analysed 98 evaluation studies from which they derived 460 estimates of the powers relating road trauma changes with travel speed changes, many of which had occurred in urban areas. They found lower powers than those originally proposed by Nilsson, but did not separately analyse the relationships applicable in urban areas. This paper reports a subsequent study based on Elvik et al's data in which the powers in Nilsson's model are estimated for urban arterial roads, residential streets, rural highways and freeways separately. It was found that there is no evidence of monotonically increasing powers connecting speed changes on urban arterial roads with increasing injury severity levels. The estimated power applicable to serious casualties on urban arterial roads was significantly less than that on rural highways, which was also significantly less than that on freeways. The implications of these findings for strategic planning predictions of the effects of speed limit reductions are discussed.

Keywords
Speed, crashes, injury severity, injuries, fatalities, modelling

Introduction

Dr Göran Nilsson apparently first published power relationships connecting traffic speeds with road trauma in English during 1981 (Nilsson, 1). Since then the relationships have been refined and the final version is given in his doctoral thesis (Nilsson, 2); see box below from Elvik, Christensen and Amundsen (3). Note that the term "injured" used in the box includes fatally injured.

The increases in fatal crashes, serious casualty crashes (those resulting in death or serious injury) and casualty crashes (those resulting in death or any injury) are each related to the 4th, 3rd, and 2nd powers, respectively, of the increase in mean traffic speed. However the increases in fatalities, serious casualties and total casualties each include a component whereby the number of such casualties per crash is related to the 8th, 6th and 4th power of the increase in mean speed.

It should also be noted that the categories of crashes and victims, by injury severity level, are not mutually exclusive. The fatal crashes/victims are included among the fatal and serious injury (i.e., serious casualty) crashes/victims who in turn are included among the all injured, including fatality (i.e., casualty) crashes/victims. Because the numbers of crashes/victims typically increases substantially with each reduction in injury severity level, the power relationship at each level of injury is considered to be an adequate empirical relationship explaining the change in the total crashes/victims at that level.

History of Nilsson's Power Model

Nilsson (2) outlines the history of research leading to his formulation of his power model. He had evaluated the outcomes from a large number of speed limit changes in Sweden during 1967-1972, assessing the changes in fatal and injury crashes while also recording the changes in mean speeds. The starting speed limits ranged from 90 km/h to 130 km/h, included decreases (and increases) of 20 km/h, and control roads where no change in speed limit occurred. A subsequent study of the reduction of the

110 km/h speed limit to 90 km/h also included an assessment of the change in serious casualty crashes and found that the changes in crashes at all three severity levels were consistent with his power model.

Box: Nilsson's (2) power model, quoted by Elvik, Christensen & Amundsen (3), TØI report 740/2004

The model can be summarised in terms of six equations that relate changes in the number of accidents or in the number of road users killed or injured in accidents to changes in the mean speed of traffic. Denote speed by V, accidents by Y, and accident victims by Z. Furthermore, subscript by 0 the values observed before a change in mean speed and by 1 the values observed after a change in mean speed. The Power model is then presented in equations 1 to 6 below:

$$\text{Number of fatal accidents} = Y_1 = \left(\frac{V_1}{V_0}\right)^4 Y_0 \qquad (1)$$

$$\text{Number of fatalities} = Z_1 = \left(\frac{V_1}{V_0}\right)^4 Y_0 + \left(\frac{V_1}{V_0}\right)^8 (Z_0 - Y_0) \qquad (2)$$

$$\text{Number of fatal and serious injury accidents} = Y_1 = \left(\frac{V_1}{V_0}\right)^3 Y_0 \qquad (3)$$

$$\text{Number of fatal or serious injuries} = Z_1 = \left(\frac{V_1}{V_0}\right)^3 Y_0 + \left(\frac{V_1}{V_0}\right)^6 (Z_0 - Y_0) \qquad 4)$$

$$\text{Number of injury accidents (all)} = Y_1 = \left(\frac{V_1}{V_0}\right)^2 Y_0 \qquad (5)$$

$$\text{Number of injured road users (all)} = Z_1 = \left(\frac{V_1}{V_0}\right)^2 Y_0 + \left(\frac{V_1}{V_0}\right)^4 (Z_0 - Y_0) \qquad (6)$$

Nilsson (2) noted that there had been very few crash investigations in urban areas of the changes in speed limits, one reason being that they had been unchanged at 50 km/h for many years in most countries. An exception was Denmark, which lowered the general urban speed limit from 60 km/h to 50 km/h in 1985 (Engel and Thomsen, 4). Another was the UK, where speed zones of 20 mph instead of 30 mph were introduced in 1990 (Webster and Mackie, 5).

The paucity of evaluation studies of urban speed limit changes quoted by the originator of the power model has raised doubts regarding whether the model is equally applicable in urban areas, or lower speed limit zones, compared with in the higher speed limit zones predominantly in rural areas where the power model was originally formulated based on a large number of studies. An opportunity to examine this question has arisen because of Elvik et al's (3) meta-analysis study of a large number (98) of evaluation studies in which 460 estimates of the effects of changes in travel speed on road trauma have been assessed. A substantial proportion of these estimates relate to relatively low speed zones in urban areas, allowing a comparison with rural areas and high speed freeways.

Evik's meta-analysis

Elvik et al (3) combined the estimates of effect in groups of estimates depending on whether the effect was measured as a change in crash numbers (at each level of severity) or victim numbers (again, at each severity level). Each estimate of effect, together with the change in mean speed associated with it, was initially interpreted as a power estimate, i.e. the power to which the speed change needed to be raised to produce the change in crashes or victims. The specific calculation of the power estimate is given by Elvik et al (3), page 55, and can result in negative power estimates if crashes or victims increased when mean speeds fell, or vice versa, as well as positive estimates as hypothesised by Nilsson (1, 2). Studies with zero crashes or victims in one or both periods were discounted from the meta-analysis because a power estimate associated with the speed change could not be calculated in these cases.

The available individual power estimates were then combined using meta-analysis techniques giving greatest weight to the most reliable estimates to produce an overall power estimate. To be consistent with Nilsson's model, they also combined groups to measure the effect as a change in serious casualty crashes or serious casualties, or total casualty crashes or total casualties.

Elvik et al conducted six different meta-analyses, two of which were based on a meta-regression technique that produced larger standard errors of the overall power estimates than a conventional technique. Two of the conventional meta-analyses considered the power estimates for mutually exclusive categories of injury level of the crashes or victims (Table 1), and two analyses considered estimates for the cumulative injury levels, i.e., fatal, serious casualty, and total casualty (Table 2). One of each pair of analyses was confined to power estimates from the subset of studies which were well controlled, i.e. they took into account "regression to the mean", long term trends in crash rates, major changes in traffic volume, and other influential factors threatening the study integrity. The studies were also checked for publication bias and little evidence of this effect was apparent.

Table 1: Elvik et al's meta-analysis results for the mutually exclusive categories of injury

Category	Source of evidence	Estimate of power	Standard error	Number of results
Fatal accidents	All studies	4.21	0.68	47
Fatal accidents	Well-controlled studies	3.65	0.83	23
Fatalities	All studies	4.90	0.16	30
Fatalities	Well-controlled studies	4.90	0.17	21
Serious injury accidents	All studies	1.35	0.34	17
Serious injury accidents	Well-controlled studies	1.59	0.84	3
Seriously injured road users	All studies	1.59	0.27	14
Seriously injured road users	Well-controlled studies	1.76	0.42	9
Slight injury accidents	All studies	0.90	0.31	17
Slight injury accidents	Well-controlled studies	1.05	0.84	3
Slightly injured road users	All studies	1.64	0.30	12
Slightly injured road users	Well-controlled studies	1.56	0.26	7
Injury accidents (unspecified)	All studies	2.76	0.30	222
Injury accidents (unspecified)	Well-controlled studies	2.61	0.55	67
Injured road users (unspecified)	All studies	1.78	1.60	15
Injured road users (unspecified)	Well-controlled studies	2.40	2.24	7
Property-damage-only	All studies	1.70	0.54	86
Property-damage-only	Well-controlled studies	0.73	0.97	17

Source: TØI report 740/2004

It can be seen that the overall power estimates for fatal crashes are close to 4, as predicted by Nilsson's model. The power estimate for fatalities is 4.9, with a relatively small standard error, suggesting that it is a reliable estimate. Elvik et al suggested a power estimate greater than 4 for fatalities is to be expected because of the 8^{th} power applicable to the fatalities per fatal crash in Nilsson's model (see equation 2 of the six equation model). The data available to Elvik et al did not allow direct estimates of the power relevant to the fatalities per fatal crash component.

The power estimates for serious injury crashes were around 1.5 and for seriously injured victims somewhat greater (but both were substantially less than a power of 3 or more expected from Nilsson's model, albeit in a cumulative injury category combined with fatal crashes/victims). The power estimates for slight injury crashes were around 1, and 1.5 for slight injuries, but were substantially greater when the power estimates from studies of all injury (severity unspecified) crashes or victims were combined by meta-analysis.

Table 2: Elvik et al's meta-analysis results for the cumulative categories of injury

Category	Source of evidence	Estimate of power	Standard error	Number of results
Fatal accidents	All studies	4.21	0.68	47
Fatal accidents	Well-controlled studies	3.65	0.83	23
Fatalities	All studies	4.90	0.16	30
Fatalities	Well-controlled studies	4.90	0.17	21
Fatal and serious injury accidents	All studies	3.41	0.54	64
Fatal and serious injury accidents	Well-controlled studies	3.29	0.72	26
Fatalities and serious injuries	All studies	3.84	0.47	44
Fatalities and serious injuries	Well-controlled studies	3.99	0.50	30
All injury accidents	All studies	2.78	0.25	303
All injury accidents	Well-controlled studies	2.67	0.43	96
All injured road users	All studies	2.86	0.44	71
All injured road users	Well-controlled studies	3.19	0.43	44
All accidents (including PDO)	All studies	2.50	0.23	389
All accidents (including PDO)	Well-controlled studies	2.15	0.39	113

Source: TØI report 740/2004

In Table 2, the overall power estimates for fatal crashes and fatalities are the same as those for the mutually exclusive injury categories. The power estimates for the serious casualty crashes ("fatal and serious injury accidents") are substantially greater than 3 and the estimates for serious casualties are nearly 4. Compared with the estimates for the (mutually-exclusive) serious injury crashes and victims, these larger estimates appear to be due to the combination with the power estimates from studies of effects on fatal crashes or fatalities, notwithstanding that there are usually larger numbers of serious injury crashes/victims than numbers of fatal crashes and fatalities. Nevertheless, the results from the meta-analysis based on cumulative categories of injury, as used by Nilsson, are consistent with Nilsson's model and suggestive of even higher powers than he proposed.

Elvik et al (3) were troubled by the absence of smoothly decreasing power estimates in each mutually exclusive injury category as the injury level decreased (Table 1). For this reason they fitted negative logarithm functions to the power estimates for the crashes and victims, separately, and produced smooth estimates. The estimates for serious injury crashes/victims were adjusted upwards, and those for all injury (severity unspecified) crashes/victims were adjusted downwards. Based on a number of rationalisations and biomechanical principles, final power estimates were produced (Table 3).

Elvik et al did not present power estimates for the cumulative categories of injury, unlike Nilsson. They preferred to present their findings for the mutually exclusive categories because of the inconsistencies which can arise from the cumulative estimates because of variations in crash and injury reporting in practice.

Table 3: Final power estimates (exponents) produced by Elvik et al (3)

Accident or injury severity	exponent	interval
Fatalities	4.5	(4.1 – 4.9)
Seriously injured road user	3.0	(2.2 – 3.8)
Slightly injured road user	1.5	(1.0 – 2.0)
All injured road users (severity not stated)	2.7	(0.9 – 4.5)
Fatal accidents	3.6	(2.4 – 4.8)
Serious injury accidents	2.4	(1.1 – 3.7)
Slight injury accidents	1.2	(0.1 – 2.3)
All injury accidents (severity not stated)	2.0	(1.3 – 2.7)
Property-damage-only accidents	1.0	(0.2 – 1.8)

Source: TØI report 740/2004

Power estimates for urban and rural areas

Elvik et al (3) did not conduct separate meta-analyses of studies of speed changes in urban and rural areas, however they did record the type of road or traffic environment on which each study was based, as follows:

(a) Motorway or freeway [urban or rural]
(b) All purpose rural highway
(c) All purpose urban highway [urban arterial road]
(d) Residential access road [residential street or collector road]
(e) All types of environment

The raw data file on which Elvik et al (3) was based, including the road environment for each individual study and power estimate, was re-analysed. The power estimates for the mutually exclusive crash and victim injury severity categories were sorted and it was found that there was only one study that contributed a power estimate for fatal crashes on urban highways. For this reason, the conventional meta-analysis technique was used only for crash victims, by injury level, to provide power estimates in each road environment. A meta-regression analysis technique was able to provide power estimates for both crashes and victims, albeit with less reliability of the individual estimates compared with the conventional technique.

Results of conventional meta-analysis

The meta-analysis was conducted from the results of all studies, not just the well-controlled studies, because of similarities of estimates found by Elvik et al (3). The powers were estimated for the mutually exclusive categories of injury of the victims (Table 4), and also for cumulative categories following Nilsson (1, 2) (Table 5). There were no studies on residential roads to provide power estimates for fatalities and for injured (unspecified) victims. However, power estimates for seriously injured and slightly injured victims on residential roads were produced, as well as a cumulative estimate for specifically injured victims (excluding fatalities) in this road environment. Estimates based on one study are shown in italics and no standard error is given, reflecting the inherent unreliability of the estimate (Table 4). These unreliable estimates should be ignored in reaching final conclusions.

Among the reliable estimates, it can be seen that substantially higher powers were estimated for freeways and rural highways than urban arterial roads. The high-speed freeway environment is associated with particularly high power estimates across all levels of injury. Rural highways are reasonably consistent with Nilsson's power model, with the cumulative estimates decreasing monotonically from 4.71 for fatalities to 2.59 for serious casualties and 2.50 for all casualties. The power estimates for the mutually-exclusive injury categories are also consistent with the monotonic decrease expected by Elvik et al (3), ignoring the relatively high, but potentially unreliable estimate for injured (unspecified).

Table 4: Power estimates (with standard errors) for victims in each road environment. Mutually exclusive categories of injury, following Elvik et al (3)

	Road environment of study				
POWER ESTIMATES (with standard errors, SE)	**Urban arterial**	**Rural highway**	**Residential road**	**Freeway**	**ALL AREAS**
Fatalities	4.251	4.711	NA	4.931	4.902
SE	*0.92*	*0.49*		*0.15*	*0.14*
Seriously Injured	1.390	1.805	*3.767 **	*3.859 **	1.593
SE	*0.24*	*0.30*			*0.18*
Slightly Injured	1.928	1.554	*1.522 **	*3.604 **	1.742
SE	*0.25*	*0.24*			*0.17*
Injured (unspecified)	*6.108 **	5.480	NA	2.770	2.780
SE		*0.44*		*0.03*	*0.03*

** Power estimates in italics were each based only on one study of effect of speed change*

Table 5: Power estimates (with standard errors) for victims in each road environment. Cumulative categories of injury, following Nilsson (1, 2)

	Road environment of study				
POWER ESTIMATES (with standard errors, SE)	**Urban arterial**	**Rural highway**	**Residential road**	**Freeway**	**ALL AREAS**
Fatalities	4.251	4.711	NA	4.931	4.902
SE	*0.92*	*0.49*		*0.15*	*0.14*
Serious casualty	1.569	2.592		4.925	3.721
SE	*0.23*	*0.26*		*0.14*	*0.11*
Casualty (including unspecified injury)	1.746	2.495		2.839	2.806
SE	*0.17*	*0.16*		*0.03*	*0.03*
Specific injured (non-fatal)			2.829		
SE			*1.45*		

It is on urban arterial roads that the expected monotonic relationship of the power estimates breaks down. The power estimate for the seriously injured victims was only 1.39, compared with 1.93 for the slightly injured, and appears to be the major contributor to the relatively low power estimate for the seriously injured across all studies (1.59) that troubled Elvik et al (3) and led to their smoothing procedure. The power estimate for fatalities was also substantially less than that on rural highways and freeways, but it was associated with a relatively high standard error. Based on 95% confidence limits of about twice the standard error in each case, none of the power estimates for the mutually-exclusive injury categories on urban arterial roads was statistically different from the corresponding estimate across all studies and road environments.

The power estimates based on the cumulative injury categories (Table 5) have the advantage that each of the non-fatal estimates is contributed to by a substantial number of studies and improves the precision of estimation lost due to sub-dividing the studies by the road environment. In this analysis there is stronger evidence of smaller power estimates associated with the studies on urban arterial roads. The power estimate of 1.57 for serious casualties on urban arterials is statistically significantly less than that on rural highways (2.59), and that is statistically significantly less than the power estimate on freeways (4.93), as indicated by non-overlapping confidence limits for each comparison. There is evidence of similar differences in the power estimates for the all casualties category across these three road environments.

Results of meta-regression analysis

As a further test of the validity of the estimates of power derived by means of a conventional meta-analysis, the results of one of the many meta-regression models that were run in the original study (Elvik et al, 3) were examined. The meta-regression model was very comprehensive and included, in addition to estimates of power applying to all categories of crash or injury severity (treated as mutually exclusive categories), coefficients capturing the effects of road environment, study design, publication type, decade in which study was reported, and use of other measures to influence speed in addition to speed limits. The estimates of power applicable to each road environment are shown in Table 6 below.

The estimates in Table 6 were derived by combining the constant term, the coefficients for the various levels of crash or injury severity and the coefficients for type of traffic environment. The coefficients for the other variables included in the model were not used. The standard errors of each of these estimates may be relatively large. Elvik et al's (3) meta-regressions of studies across all road environments found standard errors around 1.0 for each victim injury category and 0.3-0.6 for the crash severity categories. This compares with standard errors no greater than 0.18 across all road environments using conventional meta-analysis (Tables 4 and 5). Larger standard errors could be expected for the power estimates within each road environment based on the meta-regression analysis technique.

Table 6: Power estimates for victims and crashes based on meta-regression analysis

	Type of road environment				
POWER ESTIMATES	**Urban arterial**	**Rural highway**	**Residential road**	**Freeway**	**All areas**
Fatalities	3.60	5.90	4.84	5.33	4.26
Seriously injured	2.67	4.96	3.90	4.40	3.32
Slightly injured	0.90	3.19	2.13	2.63	1.55
Injured (unspecified)	0.54	2.83	1.77	2.26	1.19
Fatal accidents	2.06	4.36	3.30	3.79	2.72
Serious accidents	0.49	2.78	1.72	2.22	1.14
Slight accidents	-0.07	2.22	1.16	1.66	0.58
Injury accidents	1.25	3.54	2.48	2.98	1.90

Notwithstanding the potential unreliability of these estimates, broadly speaking the results are consistent with the Nilsson's power model, but they confirm clearly lower values for the exponent of each victim category on urban arterial roads. Apart from fatal crashes, the exponents for each of the other crash categories on urban arterials are clearly much lower than in other road environments and may not be significantly different from zero.

Discussion

Elvik et al's (3) analysis suggested that the powers to which changes in mean speed need to be raised to estimate changes in road trauma at varying levels of injury severity are not as great as those proposed by Nilsson (1, 2). Indeed, Elvik et al found that the power estimate relevant to seriously injured crash victims was substantially lower than that implicit in Nilsson's hypothesis, notwithstanding the fact that Nilsson's model includes a relationship in which the seriously injured are cumulated with fatalities, not modelled separately.

The new analysis of Elvik et al's (3) data presented in this paper suggests that the relatively low power estimate for seriously injured victims applies only to urban arterial road crashes and is not unexpectedly low for crashes on rural highways and freeways. In their evaluation of the 1985 reduction of the general urban speed limit in Denmark, Engel and Thomsen (4) found that the 3-4 km/h reduction in mean speeds was associated with 24% reduction in fatalities, 11% reduction in the slightly injured, but only 7% reduction in the seriously injured. Hoareau, Newstead and Cameron (6) found that the 2001 reduction of the Victorian general urban speed limit from 60 to 50 km/h was associated with only 3% reduction in serious injury crashes, but 16% reduction in minor injury crashes (and 21% in fatal crashes) on roads with the speed limit change where mean speeds reduced by 2-3 km/h. The evaluation of the South Australian default urban speed limit reduction in 2003 found that the 3.8 km/h mean speed decrease was associated with 40% reduction in fatalities but a smaller reduction in the seriously injured (20%) than the less severely injured (23-26%) (Kloeden, Woolley and McLean, 7).

Together these results cast doubt on the applicability of Nilsson's (1, 2) model to urban arterial roads that goes beyond Elvik et al's (3) finding that the powers applicable to the mean speed changes need to be revised downwards. The analysis and other results suggest that there is not a monotonic increase in the applicable powers as the injury severity of the victims and crashes increases, with the highest power applying to fatalities/fatal crashes. The power applicable to seriously injured victims in urban arterial road crashes appears to be lower than that applicable to the slightly injured, which in turn is lower than that applicable to fatalities. The reason for this counter-intuitive breakdown in the monotonic relationship may relate to the type of crashes which are reduced when speed limits in urban areas are reduced. Kloeden et al (7) found that there were smaller, non-significant reductions in head-on, rollover and fixed object collisions than other types of casualty crashes on the roads that reduced speed limits from 60 to 50 km/h in 2003. These types of crashes frequently result in serious injuries to car occupants. Other research has found that a major beneficiary of speed limit reductions in urban areas is pedestrian trauma.

While the estimated power applicable to seriously injured victims in urban arterial road crashes was not statistically significantly different from that in rural highway crashes, the power estimate for the cumulative serious casualty victims was. For the cumulative serious casualty victims, those involved in crashes on urban arterial roads had a lower power associated with the mean speed change than those in crashes on rural highways, who in turn had a lower power than those involved in crashes on freeways.

Implications for predictions of effects of speed limit changes

A number of strategic planning studies have predicted the likely reductions in road trauma if speed limits were decreased on urban roads. For example, Howarth, Ungers, Vulcan and Corben (8) estimated the reduction in casualty crashes in Australia if speed limits on all (former) 60 km/h limit roads had been reduced by 10 km/h. They estimated that average free speeds would reduce by 5 km/h and also considered an ambitious, but unlikely, reduction of 10 km/h. Based on Nilsson's (1) power model, they then predicted that casualty crashes would be reduced by 3,000 (or 8.5%) per year under the first scenario, and by 8,000 (or 22.5%) under the second scenario.

More recently, Corben, Logan, Johnston and Vulcan (9) have predicted the reduction in serious casualties if the current 60 km/h limit roads in Western Australia were to have their speed limit reduced to 50 km/h. They estimated that average speeds would fall by 7% and, again based on Nilsson's (1) power model, using exponents of 4 and 3 for fatalities and serious injuries respectively, they predicted that fatalities would fall by 25.2% and serious injuries by 19.6%. A similar approach has been used to predict the magnitude of the reduction in serious casualties associated with urban speed limit decreases in the planning for the Victorian road safety strategy (Corben, Logan and Schofield, 10). Each of these studies has apparently overlooked actual experience with the effects of the introduction of 50 km/h speed limits on residential streets in the Australian states, where average travel speeds have typically been reduced only to a modest extent and so have serious casualty crashes (but fatal crashes have been reduced substantially).

Elvik et al (3) had also examined the magnitude of change in mean speed associated with different speed limit changes in the sub-set of studies that evaluated such initiatives (Figure 1). Generally they found that the mean speed change (in km/h) was about one-quarter of the speed limit change (also in km/h), as can be seen from the slope of the best fit line in Figure 1.

The results in Table 5 suggest that the predictions of serious casualty reductions on urban 60 km/h limit roads (predominantly urban arterials) associated with proposed 10 km/h speed limit reductions are overstated. The analysis suggests that a power of 1.57 should be applied to the change in mean speed to estimate the expected reduction in serious casualties. Studies of free speeds on 60 km/h speed limit roads typically show that mean speeds are about the same as the speed limit (for example, Radalj, 11).

Based on Elvik et al's findings in Figure 1, this suggests that a reduction in the 60 km/h speed limit by 10 km/h would result in a reduction in mean speed of about 2.5 km/h or 4.2% of the mean speed on those roads during 2005. This in turn would suggest that the mean speed reduction would result in 6.5% reduction in serious casualties on those urban roads, based on our estimate of the appropriate power for that road environment (1.57).

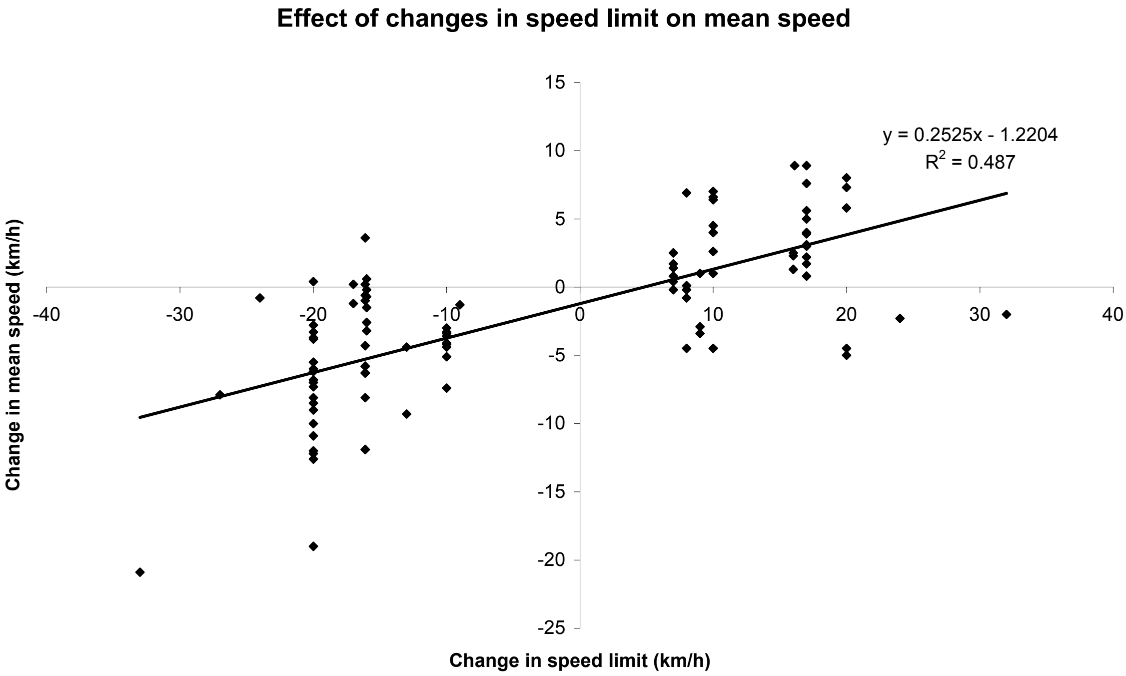

Figure 1: Relationship between change in speed limit (km/h) and resulting change in mean speed of traffic (from Elvik et al, 3)

For comparison, in the case of the 10 km/h speed limit reduction on 110 km/h speed limit roads, Figure 1 suggests the same 2.5 km/h reduction in mean speed, however the speed from which this change would occur is substantially higher. If mean free speeds on 110 km/h limit roads are about the speed limit, 2.5 km/h would represent about 2.3% reduction. The power estimates in Table 5 suggests that a mean speed reduction of this magnitude would result in 5.8% reduction in serious casualties on rural highways, but 10.7% reduction in serious casualties on freeways.

Based on the analysis above, the estimated reductions in serious casualties associated with the urban speed limit reductions appear to be substantially less than those predicted in various road safety strategic plans. Nevertheless, experience with the introduction of 50 km/h speed limits on residential streets has shown that reductions in road trauma may still result. Whether this will be achieved by reductions in average free speeds is doubtful. The mechanism of effect is likely to lie in more complex changes to the speed distribution.

Conclusions

Nilsson's power model connecting speed and road trauma is not directly applicable to traffic speed changes on urban arterial roads. There is no evidence of monotonically increasing powers applicable to the speed changes on urban arterial roads which predict the magnitude of changes in road trauma at increasing injury severity levels. The estimated power applicable to serious casualties on urban arterial roads (1.57) is substantially less than that on rural highways (2.59) which is also substantially less than that on freeways (4.93).

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