Synthesis of Safety Research Related to Speed and Speed Management

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SUMMARY

There is evidence that crash risk is lowest near the average speed of traffic and increases for vehicles traveling much faster or slower than average. The occurrence of a large number of crashes involving turning maneuver partly explains the increased risk for motorists traveling slower than average and confirms the importance of safety programs involving turn lanes, access control, grade separation, and other measures to reduce conflicts resulting from large differences in travel speeds.

When the consequences of crashes are taken into account, the risk of being involved in an injury crash is lowest for vehicles that travel near the median speed or slower and increases exponentially for motorists traveling much faster. One of the major concerns in all of the studies is the travel speed before the crash. Emerging technology used in mayday, vehicle tracking, and adaptive speed control systems provide the opportunity to accurately and continuously capture travel speed. This technology should be applied in improving our understanding of the relationship between speed, speed variation, and safety.

When a crash occurs, its severity depends on the change in speed of the vehicle at impact. The fatality risk increases with the change in speed to the fourth power. International research indicates the change in injury crashes will be twice the percentage change in speed squared, and fatal crashes will be four times the percentage change in speed. These relationships are based mainly on speed limit and speed changes on high-speed roads. More research is needed to assess their applicability to low-speed urban roads.

In general, changing speed limits on low and moderate speed roads appears to have little or no effect on speed and thus little or no effect on crashes. This suggests that drivers travel at speeds they feel are reasonable and safe for the road and traffic regardless of the posted limit. However, on freeways and other high-speed roads, speed limit increases generally lead to higher speeds and crashes. The change in speed is roughly one-fourth the change in speed limit. Results from international studies suggest that for every 1 mi/h change in speed, injury accidents will change by 5 percent (3 percent for every 1km/h). However there is limited evidence that suggests the net effect of speed limits may be positive on a system wide basis. More research is needed to evaluate the net safety effect of speed limit changes.

Most of the speed related crashes involve speed too fast for conditions. This would suggest that variable speed limits that adjust with traffic and environmental conditions could provide potential benefits.

Despite the large number of references concerning traffic calming, very few reports include results of a systematic evaluation. In many cases traffic volumes as well as speed are reduced. As a result of the traffic diversion, crashes may be migrating to other roads. More research is needed to assess the system wide impacts and permit comparisons to be made among individual as well as combinations of traffic calming measures.

SPEED LIMITS AND SPEEDS

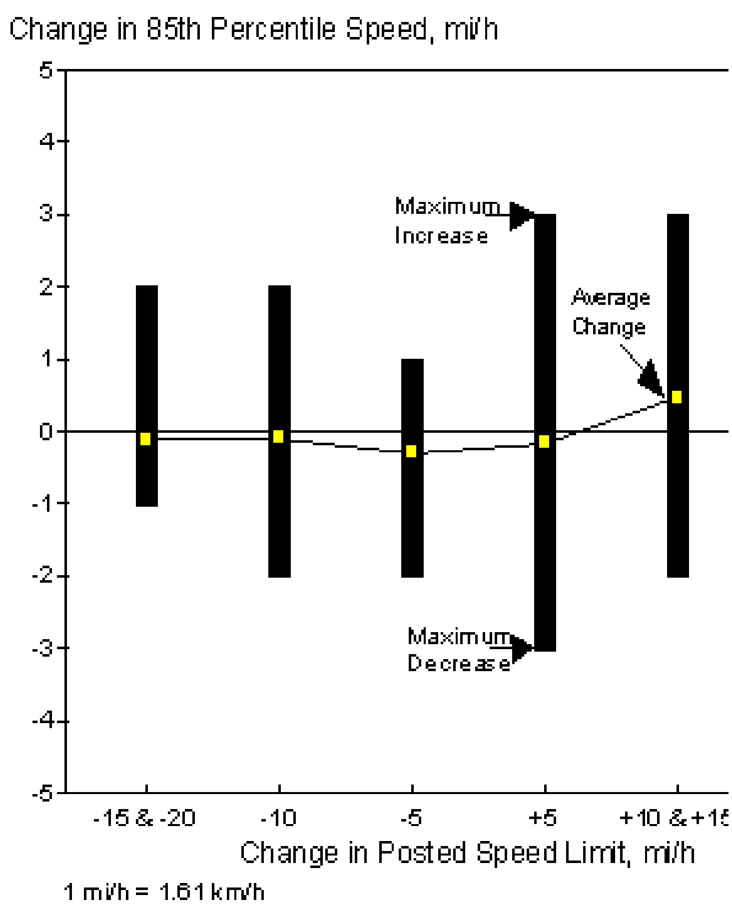

Figure 7. Effects of altering speed limits by various amounts on non-freeways (Parker, 1997).

In a survey of speed zoning practices, Parker (1985) found that all states and most local agencies consider the speed of traffic in setting speed limits. The primary factors considered in engineering studies to set speed limits were, in order of their importance:

- 85th percentile speed.
- Type and amount of roadside development.
- Accident experience.
- Adjacent Limits.
- 10 mi/h pace (i.e., speed range that contains the largest percentage of vehicles).
- Horizontal and vertical alignment.
- Design speed.
- Average test run speed.
- Pedestrians.

Criteria and procedures for setting appropriate speed limits in Australia (Fildes and Lee, 1993) and Canada (Knowles et al., 1997) are remarkably similar to the methods followed in the United States.

In general compliance with speed limits is poor. Harkey et al. (1990) found that 70 percent of the vehicles exceeded the speed limit on a representative sample of low and moderate speed roads in four States. Similar results are reported abroad by the European Transport Safety Council (1995) and in Canada by Knowles et al. (1997).

A number of studies have examined the effects of altering speed limits on speeds. Spitz (1984) reported that the 85th percentile speed of traffic increased less than 0.4 mi/h (0.6 km/h) in 40 zones where speed limits were raised in 10 California cities. This was less than the 0.7-mi/h (1.1-km/h) increase observed in the comparison sites which had no speed limit change. For the 10 zones where speed limits were lowered, speeds actually increased on average by 1.1 mi/h (1.8km/h).

Dudek and Ulman (1986) found no significant changes in speeds at six sites in the urban fringe where speed limits were lowered from 55 to 45 mi/h (89 to 72 mi/h).

Parker (1997) , taking advantage of routine speed zoning changes being made by State and local agencies, evaluated the effects of raising and lowering speed limits by various amounts at 98 non-freeway sites in 22 States.

Free-flow speeds were measured for a 24-hr period before the speed limit was altered and on the same day of the week about one year later. Before and after speeds were measured simultaneously at comparison sites where speed limits were not altered to control for time trends. As shown in figure 7, raising and lowering speed limits had little or no effect on speeds. Although maximum speed changes up to 3 mi/h (5 km/h) were observed at individual sites, the average change in the mean and 85th percentile speeds was less than 1 mi/h and similar to sites that were not changed.

However, studies in the USA and abroad generally show an increase in speeds when speed limits are raised on freeways. Changes in mean speeds ranging from 1 to 4 mi/h were observed when the speed limits in the United States were increased from 55 mi/h (89 km/h) to 65 mi/h (105 km/h) as shown in table 2.

Table 2. Speed increases observed from raising speed limit from 55 to 65 mi/h

	mi/h	km/h
Brown et al. (1990)	2.4	3.9
Freedman and Esterlitz (1990)	2.8	4.5
Mace and Heckard (1991)	3.5	5.6
Pfefer, Stenzel, and Lee (1991)	4-5	6-8
Parker (1997)	0.2-2.3	0.3-3.7

Finch et al. (1994) analyzed the changes in speeds from raising and lowering speed limits reported in a number of international studies and found that the change in mean traffic speed is roughly one-fourth of the change in the posted limit. Knowles et al.(1997) reported similar findings from observational before and after studies in Canada.

SPEED LIMITS AND SAFETY

Another way to examine the relationship between vehicle speed and traffic safety is to measure the effects of lowering or raising speed limits on the incidence and severity of crashes. Table 3 summarizes the results of studies of this type conducted in several countries. The table shows that crash-incidence or crash severity, or both measures, generally decline whenever speed limits have been reduced. Conversely, the number of crashes or crash severity generally increased when speed limits were raised, especially on freeways.

Table 3. Summary of the effects of raising or lowering speed limits.

Reference	Country	Change	Results
Speed Limit Decreases			
Nilsson (1990)	Sweden	110 km/h to 90 km/h (68 mi/h to 56 mi/h)	Speeds declined by 14 km/h Fatal crashes declined by 21%

Engel (1990)	Denmark	60 km/h to 50 km/h (37 mi/h to 31 mi/h)	Fatal crashes declined by 24% Injury crashes declined by 9%
Peltola (1991)	UK	100 km/h to 80 km/h (62 mi/h to 50 mi/h)	Speeds declined by 4 km/h Crashes declined by 14%
Sliogeris (1992)	Australia	110 km/h to 100 km/h (68 mi/h to 62 mi/h)	Injury crashes declined by 19%
Finch et al. (1994)	Switzerland	130 km/h to 120 km/h (81 mi/h to 75 mi/h)	Speeds declined by 5 km/h Fatal crashes declined by 12%
Scharping (1994)	Germany	60 km/h to 50 km/h (37 mi/h to 31 mi/h)	Crashes declined by 20%
Newstead and Mullan (1996)	Australia	5-20 km/h decreases (3-12 mi/h decreases)	No significant change (4% increase relative to sites not changed)
Parker (1997)	USA 22 states	5-20 mi/h decreases (8-32 km/h decreases)	No significant changes
Speed Limit Increases			
NHTSA (1989)	USA	55 mi/h to 65 mi/h (89 km/h to 105 km/h)	Fatal crashes increased by 21%
McKnight, Kleinand Tippetts (1990),	USA	55 mi/h to 65 mi/h (89 km/h to 105 km/h)	Fatal crashes increased by 22% Speeding increased by 48%
Garber and Graham (1990)	USA (40 States)	55 mi/h to 65 mi/h (89 km/h to 105 km/h)	Fatalities increased by 15% Decrease or no effect in12 States
Streff and Schultz (1991)	USA (Michigan)	55 mi/h to 65 mi/h (89 km/h to 105 km/h)	Fatal and injury crashes increased significantly on rural freeways
Pant, Adhami and Niehaus (1992)	USA (Ohio)	55 mi/h to 65 mi/h (89 km/h to 105	Injury and property damage crashes increased but not fatal crashes

		km/h)	
Sliogeris (1992)	Australia	100 km/h to 110 km/h (62 mi/h to 68 mi/h)	Injury crashes increased by 25%
Lave and Elias (1994)	USA (40 states)	55 mi/h to 65 mi/h (89 km/h to 105 km/h)	Statewide fatality rates decreased 3-5% (Significant in 14 of 40 States)
Iowa Safety Task Force (1996)	USA (Iowa)	55 mi/h to 65 mi/h (89 km/h to 105 km/h)	Fatal crashes increased by 36%
Parker (1992)	USA (Michigan)	Various	No significant changes
Newstead and Mullan (1996)	Australia (Victoria)	5-20 km/h increases (3-12 mi/h increases)	Crashes increased overall by 8% 35% decline in zones raised from 60-80
Parker (1997)	USA 22 states	5-15 mi/h (8-24 km/h)	No significant changes

Parker (1992) found little change in crashes on low and moderate speed roads in Michigan where speed limits were altered under the State's normal speed zoning process. For the 21 sites where the speed limit was increased, crashes decreased about 3 percent compared to sites not changed. Crashes also decreased approximately 2 percent at the 47 sites where speed limits were lowered. Neither change was statistically significant.

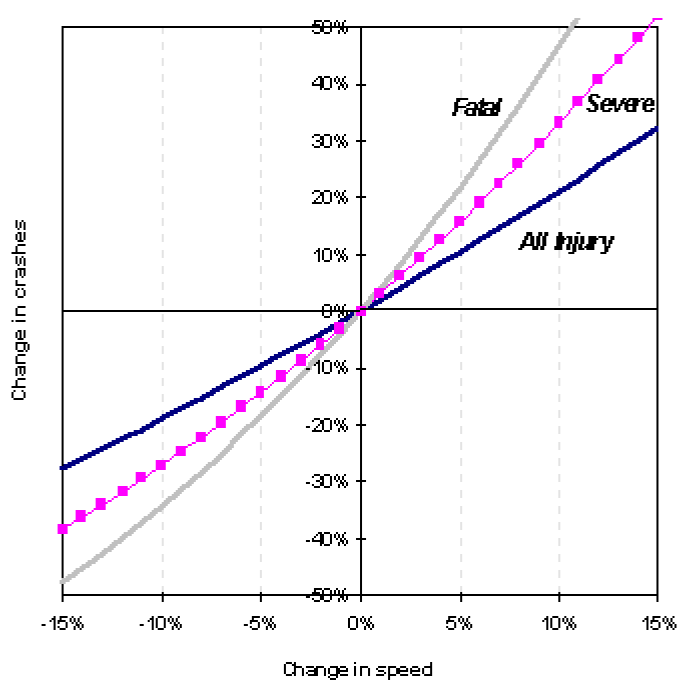

Figure 8. Effects of changes in the speed on injury and fatal crashes (from Nilsson, 1981).

Parker (1997) found no significant changes in total or injury crashes for the 98 sites where speed limits were altered in the 22 States. This should not be surprising since, as discussed in the previous section, there were little or no change in speed. Compared to sites not change, crashes increased on the average 7 percent at sites where the speed limits were lowered and decreased on the average 11 percent where the speed limits were increased.

Based on the investigations of 50 separate speed limit changes on urban and rural roads in Sweden, Nilsson (1981) derived a series of mathematical functions that explain the relationship between changes in a speed limit and traffic safety. Figure 8 illustrates Nilsson's calculations, which predict increases in fatal crashes as the change in vehicle velocity by a factor of 4, severe injury crashes by a factor of 3, and all injury crashes by a factor of 2.

Based on the effects of speed limits reported in various international studies, Finch et al. (1994) developed a model of the relationship between the change in mean speed and the change in crashes. The results suggest that for every 1 mi/h change in speed, the number of injury crashes increases 5 percent or a 3-percent increase in injury crashes for every 1-km/h increase in speed.