



Freeway speed limits and traffic fatalities in Washington State

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Abstract

Background: In 1987 individual states in the USA were allowed to raise speed limits on rural freeways from 55 to 65 mph. Analyses of the impact of the increased speed limits on highway safety have produced conflicting results. **Objective:** To determine if the 1987 speed limit increase on Washington State's rural freeways affected the incidence of fatal crashes or all crashes on rural freeways, or affected average vehicle speeds or speed variance. **Design:** An ecological study of crashes and vehicle speeds on Washington State freeways from 1974 through 1994. **Results:** The incidence of fatal crashes more than doubled after 1987, compared with what would have been expected if there had been no speed limit increase, rate ratio 2.1 (95% confidence interval (CI), 1.6–2.7). This resulted in an excess of 26.4 deaths per year on rural freeways in Washington State. The total crash rate did not change substantially, rate ratio 1.1 (95% CI, 1.0–1.3). Average vehicle speed increased by 5.5 mph. Speed variance was not affected by the speed limit increase. **Conclusions:** The speed limit increase was associated with a higher fatal crash rate and more deaths on freeways in Washington State. © 2001 Elsevier Science Ltd. All rights reserved.

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1. Introduction

In 1974, a nationwide maximum speed limit of 55 mph was mandated in the USA. Although the reason for this mandate was to conserve oil during the energy crisis of 1973–1974, there was a subsequent decline in freeway deaths per mile driven. In 1987, the 55 mph mandate was relaxed when the Surface Transportation and Uniform Relocation Assistance Act allowed states to raise speed limits to 65 mph on rural freeways. A total of 38 states raised speed limits on rural freeways during 1987, and two more states did so in 1988 (National Highway Traffic Safety Administration, 1992).

Five published studies have used crash data from a single state to examine fatal crash incidence after speed limits were increased in 1987, and all reported an increase in fatalities; the increases ranged from 18% in

Alabama to 93% in New Mexico (Gallagher et al., 1989; Brown et al., 1990; Wagenaar et al., 1990; Rock, 1995; Ledolter and Chan, 1996). Eight published studies have used national data, and they have produced conflicting results. McKnight and Klein found a 27% increase in fatal accidents on 65 mph highways, but also reported a 10% increase in fatal accidents on 55 mph highways in states that did not raise the speed limit (McKnight and Klein, 1990). Baum and colleagues reported an increase of 15% in the first year after the speed limit change (Baum et al., 1989), and an increase of 26% in the second year (Baum et al., 1990). Garber and Graham inappropriately used linear regression to analyze state-by-state monthly fatality counts, which are not normally distributed, and concluded that the speed limit increase was associated with more fatalities in some states, fewer fatalities in some states, and had no effect in some states (Garber and Graham, 1990). Lave and Elias used the assumption that total statewide traffic fatalities are a better measure of the effect of the rural freeway speed limit increase than

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rural freeway fatalities are, and ignored the long-term downward trend in traffic fatalities, to conclude that the higher speed limit resulted in fewer fatalities (Lave and Elias, 1994). The National Highway Traffic Safety Administration reported that the speed limit increase was associated with a 30% increase in rural freeway fatalities in states which adopted the higher speed limit, and was responsible for an increase of 539 fatalities per year nationwide for the period through 1990 (National Highway Traffic Safety Administration, 1992). Chang and Paniati (1990) and Chang et al. (1993) concluded that the increased speed limits did not result in more fatalities, even though their data and analyses appeared to show otherwise.

Some traffic engineers believe that higher speed limits may actually save lives. This belief is supported by views stated in influential traffic engineering reference works; that the 85th percentile of vehicle speeds is a good speed at which to set the speed limit, that speed variance (the difference between the average and 85th percentile speeds) is more important than speed limits in determining crash rates, and that speed variance may decrease if speed limits are raised to the 85th percentile (Warren, 1982; Pline et al., 1992). Despite the importance of these views in determining speed limits, there has been little analysis in the literature on the effect of the speed limit increase on average vehicle speeds or speed variance.

The specific aims of this study were to estimate the effect of the speed limit increase on the incidence of fatal crashes and total crashes on rural freeways, on average vehicle speeds, and on speed variance.

2. Methods

The Washington State Traffic Safety Commission provided us with annual counts of fatal crashes, all crashes, fatalities, and vehicles miles traveled on rural and urban interstate freeways in Washington State during 1970–1994. A single crash may involve one, two or more vehicles, and a fatal crash is a crash event in which one or more persons are killed. They also provided the average speed and the 85th percentile speed, but speed data were not available for 1994, or for rural freeways for 1987, and were not available by type of freeway during 1970–1974. These data were collected by the Washington State Department of Transportation (WADOT).

The speed data were taken from the annual speed studies conducted by WADOT. As part of compliance with the federally mandated speed limits, WADOT monitored traffic at locations chosen within 33 randomly selected 5-mile segments of all 55 mph highways in the state. The number of freeway monitoring stations varied each year from as few as 12 to as many as 19.

After 1987, WADOT voluntarily continued monitoring speeds on 65 mph highways. Vehicle speeds were monitored by radar until 1981, and by automatic sensing devices after that. The vehicle count at these locations was used to estimate the total number of vehicle miles traveled (VMT) on freeways within the state.

We used Poisson regression (Frome, 1983; Breslow and Day, 1987; McCullagh and Nelder, 1989; Kuhn et al., 1994) to analyze the association between the fatal crash rate (fatal crashes per vehicle mile traveled) and the speed limit increase. In Poisson regression the outcome is the natural logarithm of the predicted count. The natural logarithm of the denominator for the rate, vehicle-miles, was entered into the model as an 'offset' term, i.e. a predictor variable with an assumed regression coefficient of 1. Poisson regression is an appropriate method to use for data that follow a Poisson distribution, as traffic accident counts generally do (Nicholson and Wong, 1993; Miaou, 1994). Data for the years 1974 through 1994 were used in the regression analysis. To correct for possible overdispersion, we refit final models using negative binomial regression (Breslow, 1984; McCullagh and Nelder, 1989). We examined residuals to look for residual serial correlation, outliers, and overly influential observations, and evaluate the fit of the model. We performed similar analyses of the association between the speed limit increase and the fatality rate, and the association between the speed limit increase and the incidence of all crashes (fatal and nonfatal).

The measure of speed variance commonly used by traffic engineers is the difference between the average speed and the 85th percentile speed. Since speeds are approximately normally distributed, this difference is approximately equal to the standard deviation of vehicle speeds. We compared average speed, 85th percentile speed, and speed variance before and after the speed limit increase, using graphic methods.

The crash data include information for both rural and urban interstates, but the speed limit was raised only on rural interstates. There has been a secular decline in crash rates since 1974 on urban interstates, and on rural interstates, except for the increase in 1987 and 1988. We incorporated a linear year term in the regression models in order to account for this secular trend. We incorporated a term describing place (rural/urban) in order to control for possible confounding by place. Since the speed limit change occurred partway through 1987, we excluded the 1987 rural data from the models.

3. Results

Fatal crash rates dropped around the time that the 55 mph mandate went into effect, but it appears that

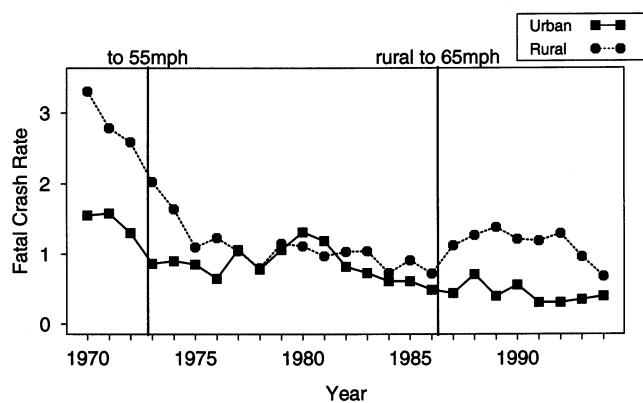


Fig. 1. Fatal crash rates (fatal crashes per 100 million miles traveled) on Washington State interstate freeways. The vertical lines show the date at which the 55 mph speed limit went into effect (November 1973), and the date rural interstates adopted the higher 65 mph speed limit (April 1987).

the start of the decline predated the mandate (Fig. 1). Rural and urban rates were similar during 1979–1986, and each showed a gradual decline. This pattern changed in 1987, when rural rates increased, while urban rates stayed relatively constant. Interstate crash rates, for fatal and nonfatal crashes combined, decreased in the early 1970s, but remained fairly constant after that (Fig. 2). After 1974, crash rates on urban interstates were about twice as high as rates on rural interstates. Rural interstate crash rates did not increase substantially after the speed limit change in 1987.

The adjusted incidence rate ratio for fatal crashes on rural freeways after the speed limit increase was 2.1 (95% CI 1.6–2.7), compared with what would have been expected had the speed limit not changed (see Table 1). An examination of residuals showed that the model provided a good fit to the data, and there was no evidence of significant residual serial correlation. The adjusted incidence rate ratio for fatalities on rural

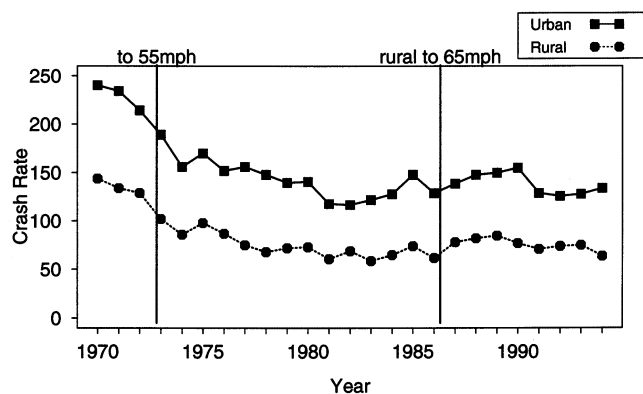


Fig. 2. Overall crash rates (crashes per 100 million miles traveled) on Washington State interstate freeways. The vertical lines show the date at which the 55 mph speed limit went into effect (November 1973), and the date rural interstates adopted the higher 65 mph speed limit (April 1987).

freeways after the speed limit increase was 2.2 (95% CI 1.6–2.9), compared with what would have been expected. The speed limit change appeared to have little association with the incidence of all crashes, adjusted rate ratio 1.1 (95% CI 1.0–1.3) for the rate ratio due to the speed limit change.

The average rural interstate speed for the 5-year period preceding the speed limit increase, 1982–1986, was 58.5 mph (Fig. 3). During the first 5 years after the speed limit change, 1988–1992, the average was 64.0 mph, an increase of 5.5 mph. Over the same time periods, the 85th percentile rural interstate speed increased from 64.0 to 70.6 mph, an increase of 6.6 mph. Speed variance, the difference between the 85th percentile speed and the average speed, has consistently increased on both rural and urban freeways since 1980, and the increase was not affected by the speed limit change (Fig. 4).

4. Comment

This study suggests that the fatal crash rate on Washington State's rural interstates was 110% (95% CI 60–170%) higher after 1987, when the speed limit was raised to 65 mph, than it would have been if the speed limit had not been changed. The total crash rate showed little change, suggesting that fatal crash incidence can rise even in the absence of an increase in total crashes. Average and 85th percentile vehicle speeds both increased on rural freeways after the speed limit increase. The speed variance on rural highways did not show any change that was associated with the speed limit increase.

Many factors are associated with fatal crashes, such as road conditions, roadway and vehicle design, age of driver, and alcohol use. Our analysis accounted for the secular trend in crash rates by utilizing urban freeway data. It is possible that some factors might have changed on one type of freeway, but not the other, at the same time that the speed limit changed. However, we are not aware of any factor that could explain the large association that we found between the speed limit change and the fatal crash rate.

The increase in the fatal crash rate in Washington was larger than was found in any of the five published studies that used data from a single state, or in any of the national studies. A reason for the large effect in Washington State may have been the large increase in the average speed, which increased from an average of 58.5 mph during 1982–1986 to an average of 64.0 mph during 1988–1992. Three other studies (Gallagher et al., 1989; Brown et al., 1990; Ledolter and Chan, 1996) reported the size of the speed increase. Only in Iowa, where the average speed increased from 59 mph in 1985–1986 to 66 mph in 1990–1991 (Ledolter and

Table 1
Final negative binomial model for the relationship between fatal accident rate and the speed limit change, year, and urban versus rural freeway

	Regression coefficient	S.E.	Risk ratio	95% CI for risk ratio
Speed limit change	0.73	0.136	2.1	(1.6, 2.7)
Year (per year)	-0.057	0.0073	0.94	(0.93, 0.96)
Urban versus rural	-0.22	0.092	0.81	(0.67, 0.96)

Chan, 1996), was the speed increase as large as it was in Washington. If the incidence of fatal freeway crashes does depend on speed limits, as the present study suggests, then the effect of a speed limit change is likely to depend on the magnitude of the change in vehicle speeds. This may differ substantially between states.

Another possible reason why a larger effect was found in Washington is that the effect may have been more accurately estimated in this study than in some others — we used appropriate regression models for count data, and used several years of data after the speed limit took effect. The studies in New Mexico (Gallagher et al., 1989), Michigan (Wagenaar et al., 1990), and Alabama (Brown et al., 1990) each relied on a single year of data after the speed limit increase. The Alabama study also did not take into account the long-term downward trend in traffic fatalities.

There was an average of 48.4 fatalities per year on rural interstates in Washington State during 1988–1994. The average number of fatalities that would have been expected in the absence of the speed limit increase is 22.0 per year. Therefore, the speed limit increase was associated with an excess of 26.4 fatalities per year on rural freeways.

Many traffic engineers hold the view that most drivers pay little attention to the posted speed limit, and drive at a speed which feels comfortable and safe (Pline et al., 1992). If this is true, then raising the speed limit would not affect the driving speed of most people, and may serve mainly to bring the speeds of the minority of drivers who do observe the speed limit up closer to the speed of other drivers, thus decreasing the speed variance. The 85th percentile speed is considered an important benchmark by traffic engineers and is often considered a good speed at which to establish the speed limit safe (Warren, 1982; Pline et al., 1992). Some traffic engineering references assert that cars traveling at the 85th percentile speed have the lowest crash involvement rate, indicating that this must be a safe speed at which to drive (Warren, 1982).

Another influential traffic engineering view is that speed variance is an important component of traffic safety — less variance in speed between drivers on a given roadway should lead to fewer crashes, and greater variance to more crashes (Warren, 1982). This implies that if raising the speed limit causes speed variance to decrease, then the higher speed limit may actually re-

duce the number of crashes and fatalities. Therefore, setting the speed limit at the 85th percentile speed may have safety advantages. Much of the research on which these views are based was conducted by Solomon (1964) and Cirillo (1968) in the 1950s and 1960s.

The results of this study do not support using these views to justify setting speed limits at the 85th percentile of speed. When the speed limit was increased on rural freeways, there was a prompt and substantial increase in both the average speed and the 85th percentile speed. This suggests that most drivers were influenced by the posted speed limit, and did not simply drive at the speed at which they felt comfortable. However, the speed limit was increased by 10 mph, while average speed increased by only 5.5 mph, suggesting that although the speed limit had a strong influence on vehicle speeds, it was not the only influence.

Speed variance was not affected by the speed limit change, indicating that both slow drivers and fast drivers increased their speed by about the same amount. If there are safety advantages to lowering the speed variance, they were not realized here, because raising the speed limit failed to lower the speed variance.

In their nationwide study McKnight and Klein (1990) observed an increase in the proportion of drivers exceeding 65 mph in states that had not raised the speed limit and proposed that the increase in speed was

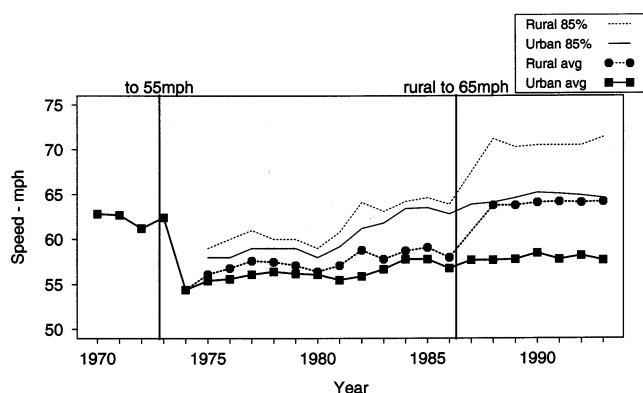


Fig. 3. Average and 85th percentile speeds on Washington State interstate freeways. The solid lines represent urban freeway speeds, and the dashed lines represent rural freeway speeds. The vertical lines show the date at which the 55 mph speed limit went into effect (November 1973), and the date rural interstates adopted the higher 65 mph speed limit (April 1987). Speed data were not reported separately by freeway type during 1970–1974.

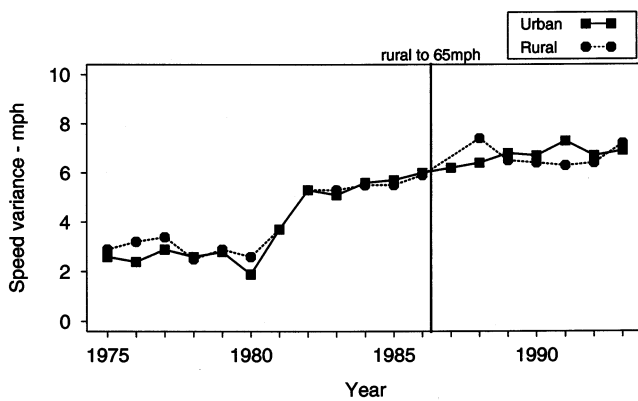


Fig. 4. Speed variance, as measured by the difference between the 85th percentile speed and the average speed, on Washington State interstate freeways. The vertical line shows the date at which rural interstates adopted the higher 65 mph speed limit (April 1987). The rural freeway data for 1987 are not shown.

as much due to a public perception that it was acceptable to drive faster as it was due to the increase in speed limits. Their data show a steady increase in the proportion of drivers exceeding 65 mph during the years before the speed limit change. In Washington State a small increase in both average speed and 85th percentile speed occurred on both rural and urban freeways between 1981 and 1986, but a far larger increase in speeds occurred only on rural freeways when the speed limit changed. This suggests that, at least in Washington State, the higher speed limit encouraged drivers to drive faster.

McKnight and Klein (1990) and Lave and Elias (1994) speculated that the higher speed limits on rural freeways would attract drivers from other roads, and that it would especially attract drivers who like to drive fast. This could lead to a decrease in fatal crashes on other roads, and, therefore, should be considered when evaluating the effect of the speed limit increase. However, this theory is not likely to account for our findings. The geography of rural freeways in Washington State is such that drivers rarely have a real choice between using the freeway or using another highway. In fact, VMT on rural freeways dropped in the 2 years following the speed limit increase, and increased only 11% in the 5 years after the speed limit increase, compared with the 5 years before, while VMT on urban freeways increased by 23% in the same period (data not shown).

The speed limit could potentially affect the fatal crash rate in two ways, by leading to an increase in the number of crashes, or by leading to an increase in the severity of crashes. In Washington State, the overall crash rate showed little change after the speed limit increase. Three other studies reported overall crash rates; the Illinois and Alabama studies each reported an

increase in the crash rate (Brown et al., 1990; Rock, 1995), but the New Mexico study found a decrease in the overall crash rate (Gallagher et al., 1989). Therefore, it appears that higher speed limits can cause an increase in fatalities even when there is not an increase in crashes. This implies that studies which consider only crash rates, such as the early studies by Solomon (1964) and Cirillo (1968), should not be used to justify increased freeway speed limits.

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