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# Safety Impacts and Other Implications of Raised Speed Limits on High-Speed Roads

**DETAILS**

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## SAFETY IMPACTS AND OTHER IMPLICATIONS OF RAISED SPEED LIMITS ON HIGH-SPEED ROADS

This digest summarizes the results of NCHRP Project 17-23, "Safety Impacts and Other Implications of Raised Speed Limits on High-Speed Roads." The digest is based on a report by Kara Kockelman of the University of Texas at Austin under subcontract to Jon Bottom of CRA International. The project objective was to determine the effects of raised speed limits from 55 mph or greater on freeways and non-freeways, in both rural and urban settings. The effects considered included safety, operations, socioeconomics, and environmental. The final report is available on the TRB website as *NCHRP Web-Only Document 90.*

## SUMMARY

This report describes the analyses performed and results obtained by a study of safety and other impacts of speed limit changes on high-speed roads. The information will be valuable for researchers studying the complex relationship between safety and vehicle speeds. The information also highlights limitations in the data needed to make sound regulatory decisions.

Safety-related analyses were based on a comprehensive framework of the disaggregate relationships among speed limits, driver speed choices, crash occurrences, and crash severities. Using various datasets, the project conducted numerous statistical analyses to elucidate and quantify these relationships. A speed limit increase on a high-speed road is generally associated with a less-than-equivalent increase in average vehicle speed: a 10-mph speed limit increase, for example, corresponds to average speeds around 3 mph higher. The project identified a relatively small but statistically significant correspondence between speed limits and total crash rates: a speed limit increase from 55 to 65 mph on an "average" high-speed road section would be associated with a crash rate increase of around 3%. Finally, the project found a statistically significant association between speed limits and the distribution of injury severities following a crash.

The magnitude of some of these relations between speed limit changes and safety factors is subject to uncertainty because of data limitations. The study is largely based on data from Washington State, and certain key years are missing. Furthermore, most of the available datasets had data on roads with different speed limits, rather than before-after data on roads that experienced speed limit changes. However, observing injury rate changes on a single road after a speed limit increase is not the same as observing injury rate differences across two existing roadways with different speed limits. Average speed differences are estimated to be higher in the latter, on the order of 6 mph (rather than 3 mph) for every 10-mph difference in speed

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limit. This data distinction is expected to translate into overestimates of the magnitude of the injury severity distribution changes following a speed limit change. Nonetheless, even after allowing for such effects, the relationship between typical speed limit changes on high-speed roads and the injury severity distribution would, in many cases, remain statistically and practically significant.

The investigation of non-safety impacts relied on published literature, unpublished reports by state DOTs of speed limit change effects, and results of surveys of state DOT and police officials. The study considered economic, environmental, and other non-safety impacts of speed limit changes. Higher speeds resulting from a speed limit increase lead to travel time savings that have an economic value. The vehicles most likely to experience such savings are those making long-distance trips primarily in rural areas, where vehicle speeds are not significantly constrained by congestion. On the other hand, vehicles have higher operating costs at higher speeds; for a typical passenger car trip, the operating cost increase associated with a speed limit increase of 55 to 65 mph is roughly one-half the value of the reduced travel time. Approaches for determining the economic costs of injuries and fatalities were also reviewed. Little is known regarding the air quality and noise impacts of speed limit changes; the few available studies suggest that these effects are very small to negligible. No reliable information was found regarding possible effects of speed limit changes on business and commerce. Similarly, available data do not allow definite conclusions to be drawn regarding the effects of differential light/heavy vehicle speed limits.

The study offers recommendations for improvements in data collection that could yield a more rigorous analysis of the effects of speed limit changes. Although the present study offers an incremental step in the analysis of speed limit impacts, it is not expected that the results are sufficient to affect regulatory decisions.

## BACKGROUND

Three major changes in national-level speed limit policy have occurred since 1974:

- On January 1, 1974, President Nixon signed into law a National Maximum Speed Limit (NMSL) of 55 mph. The law established a maximum speed limit applicable to all states and roadways and provided for penalties (the withholding of federal highway funds) for states that allowed traffic speeds in excess of 55 mph.
- The Surface Transportation and Uniform Relocation Assistance Act, enacted on April 2, 1987, relaxed the 1974 federal NMSL mandate by allowing states to set speed limits of up to 65 mph on interstate roadways passing through areas with population less than 50,000 (“rural interstates”).
- The NMSL was completely repealed by the National Highway System Designation Act, which President Clinton signed into law on November 28, 1995. Section 205(d) of this law returned to states the authority to set speed limits (or, indeed, to not establish speed limits at all) on the roadways within their boundaries, effective December 8, 1995.

Most states have used the authority granted in the 1987 and the 1995 legislation to increase speed limits on some categories of roadway.

Despite numerous studies of the effects of these speed limit increases, it is fair to say that the effects of increases on traffic safety are not yet completely understood. Traffic statistics show that aggregate crash rates have not risen dramatically since the speed limit changes and, indeed, some scholars have suggested that highway fatalities have actually *fallen* as a result of the increased limits. In fact, the empirical research has left about as many questions unanswered as it has been able to answer, and much controversy remains in both the academic and the practitioner communities regarding the relationships between traffic safety and speed limits.

With this background, the NCHRP issued in mid-2002 a Request for Proposals for Project 17-23, “Safety Impacts and Other Implications of Raised Speed Limits on High-Speed Roads.”

NCHRP Project 17-23 is generally intended to provide guidance for state highway officials and transportation policymakers concerned with evaluating and setting highway speed limits. The study’s primary objective is to extract from available data useful answers to questions such as

- What is the relationship among speed limits, actual driver speeds, and the crash characteristics of different highways? How can highway officials use available data to make informed judgments about the likely effect of changes in speed limits on driver behavior, crash rates, and the severity of crashes on a stretch of roadway?

- What are the *systemwide* effects when a speed limit is changed on a particular road-segment, apart from the safety implications on those segments themselves? Are there significant implications for safety on other roadways? Are there effects on the environment or the economy due to the traffic changes that result when speed limits are changed?

Although the primary emphasis of the study is on the safety impacts of speed limit increases, the project scope of work stipulated that some attention should be paid to their non-safety implications as well.

The study comes at a propitious time: recent years have seen the development of both *new data* sources and *methodological advances* that are applicable to the analysis of traffic safety issues. Past traffic safety analyses have not always paid adequate attention to issues of statistical methodology. For example, an appropriate definition of the "before" and "after" cases when investigating the effects of a traffic safety measure or an appropriate recognition of the effects of data aggregation is lacking. In recent years, however, traffic safety researchers have become much more aware of these issues, and, in some cases, have developed methods to address or circumvent the analytical difficulties. In cases where this has not been possible, the limits of valid statistical inference are at least now clearer than they might have been in the past.

Moreover, the increasingly broad deployment of automatic traffic data collection equipment, particularly since the NMSL repeal, is producing a large set of vehicle count, detector occupancy and, in some cases, speed measurements, covering individual highways and sometimes entire highway systems. In some cases, these data are available at a level of disaggregation that reduces some of the statistical difficulties created by data grouping. Such dynamic traffic data, when combined with crash reports and descriptions of highway characteristics, provide a very detailed description of the traffic environment at or around the time of a crash and lend themselves to detailed analyses of factors that influence crash occurrence.

## APPROACH

NCHRP Project 17-23 is a study of the safety and other effects of speed limit changes on high-speed roads. The work was carried out by a team consisting of Professor Kara Kockelman and her students, and CRA International, Inc. Kara Kockelman is an Associate Professor at the University of Texas at Austin.

To accomplish the project objectives, the project team carried out activities in a number of areas:

- A review of relevant literature, covering a broad range of topics relevant to this study. These included prior studies of the safety impacts of speed limit changes, discussions of statistical methodology applicable to the particular issues presented by traffic safety analyses, reviews of non-safety impacts of speed limit changes, and analyses of the effects of differential speed limits between light-duty and heavy-duty vehicles (e.g., cars and trucks).
- An Internet-based survey of state DOTs. The survey focused on each DOT's decision-making processes about speed limit changes, but also obtained basic information about traffic volume and safety data availability and other issues.
- Telephone surveys of state highway patrols or equivalent agencies. Here, the intent was to obtain information regarding the responses of these agencies to the NMSL repeal, especially regarding changes in the deployment of traffic enforcement resources.
- Collection of data relating to the effects of speed limits on traffic safety and the analysis of this data to identify and quantitatively model the various ways in which speed limits directly and indirectly affect safety. Analyses of speed choices (their central tendencies and variability) were undertaken for data from high-speed roadways in several regions (i.e., Washington State, Southern California, and Austin, Texas). Crash frequency was modeled as a function of roadway design and use characteristics and relied on both discrete and continuous models of panel data from across Washington State. Crash severities were modeled using heteroscedastic ordered logit models, as applied to both Washington and U.S. datasets. These analyses were the major focus of the project effort and were primarily carried out by Kara Kockelman and her students.

The principal analyses and conclusions of this work are summarized below.

## SAFETY IMPACTS OF SPEED LIMIT CHANGES

The safety-related analyses were based on a comprehensive framework of the disaggregate relationships among speed limits, driver speed choices, crash occurrences, and crash severities. The analyses drew on various data types, including loop detector measurements; stated preference surveys and revealed choices; and crash records containing information about crash counts and severities, vehicles and their occupants, and roadways and their environments. The project made extensive use of data obtained from Washington State because of its quality and state of preparation. However, data from a national driver safety survey; vehicle speed data from Southern California and Austin, Texas; and a national sample of crash records were also used. The analyses applied state-of-the-art statistical methods to address a number of data characteristics that complicate traffic safety analyses. The project's datasets and analyses are thoroughly described in Chapter 4 of the contractor's final report, available as part of *NCHRP Web-Only Document 90.*

Following the project's original scope of work, the data, analyses, and conclusions pertain to speed limit increases on high-speed roads. Most (but not all) of the data concerned high-speed roadways (e.g., Interstates and freeways) with full access control. The conclusions cannot be extended to predict the safety impacts that might be associated with speed limit increases on lower-speed roadways.

### Speed Choice Models

Analyses of driver speed choices were intended to illuminate the relationships between speed limits and actual driver behavior, as this is reflected in average vehicle speeds and speed variability. A number of analyses were carried out; two in particular are highlighted here.

A study of speed limit changes in Washington State was based on a before-after comparison of four sites: two urban and two rural, as well as two that experienced speed limit changes and two that did not. The analysis showed that a 5 mph speed limit increase at two sites was associated with an increase in average speeds of 1.2 to 1.6 mph, and with a 5 $mph^2$ ($mi^2/h^2$) speed variance increase at the rural site. Over the same period, the sites that did not experience a speed limit change exhibited essentially no changes in their traffic speed characteristics, suggesting that the "spillover" effect (the effect that a speed limit change on one road may have on parallel facilities) in this case was small or negligible.

The analysis of individual vehicle speed data was obtained from a small cross section of a dataset of radar gun speed measurements on roadways in Austin, Texas. This was the only source of individual vehicle speed data available to the project, and speed limits were not changed during the study period. The analysis identified engineering, environmental, and traffic characteristics that influence average speed and speed variance. Comparing different roadway sections in the cross-sectional analysis, it was found that a 5-mph difference in speed limits was associated with a roughly 3.2-mph difference in average vehicle speeds. A particular highlight of this analysis was its demonstration that the effect of speed limits on vehicle speed *variances* is, at most, very small.

The before-after analysis of vehicle speeds on roads that experience a speed limit change suggests a much more moderate response to the change than does the cross-sectional analysis of speeds on roadways with different limits (e.g., 3-mph change in actual speeds following a 10-mph change in speed limits, rather than the 6-mph change that a cross-sectional analysis would suggest). Existing literature, which is frequently based on before-after analyses, also tends to support the lower result. Most of the project's speed choice model analyses involved cross-sectional data, however, because the Washington State sample of before-after data speed and crash data was thought to be too small for use in disaggregate model development. Consequently, the magnitude of the effects of speed limit changes on average speeds may be overestimated here.

Moreover, because predictions of the overall effects of a speed limit change on safety depend in part on expected driving speed changes, an overestimate of the latter will propagate through the model system and may lead to an overestimate of the overall safety effects of a speed limit change. This caveat should be kept in mind when examining predictions of overall speed limit change effects. However, even allowing for a possible overestimate of these effects, the magnitudes of the speed limit change effects remain in most cases both statistically and practically significant.

## Crash Occurrence Models

The results of the project analyses of the statistical association between speed limits and total crash rates suggested only slight effects. The project's main work on crash occurrence models was based on datasets obtained by clustering Highway Safety Information System (HSIS) roadway segments over several years of data.

Two separate analyses of this dataset found that, other things being equal, the statistical relationship between speed limit and total crash rate is concave, with a maximum around 70 mph. (This was the highest observed speed limit in the dataset, and the model was not extrapolated beyond that value.) For a "typical" high-speed roadway section, a 10-mph speed limit increase is associated with a 2.9 to 3.3% increase in the overall crash rate.

## Injury Severity Models

Injury severity models apply when crashes have occurred and are then used to estimate the associated distribution of injury severities.

The project used HSIS data for Washington State as well as the National Automotive Sampling System (NASS) Crashworthiness Dataset (CDS) to estimate occupant-based injury severity models.

Both models are consistent in that they associate sizeable percentage increases in the rates of incapacitating and fatal injuries with a 10-mph or higher speed limit increase. However, the magnitudes of the increases calculated by the two models are quite different. For typical speed limit increases, the model developed from Washington State data on high-speed roads predicts an increase in fatalities in the range of 7 to 39% following a crash, while the model estimated from NASS CDS data on all roads predicts crash fatality rate increases in the range of 31 to 110%, or roughly twice as high. Of the two sets of results, it is likely that the model developed from Washington State HSIS data is more applicable to the analysis of speed change impacts on *high-speed* roads because the estimation dataset contained only data on such roads. The NASS dataset offered a much wider range of roadway types and speed limits; thus, its speed-related results are more striking. (It is rare that vehicle occupants die on low-speed roadways.) For this reason, the lower range of fatality rate changes is likely to be more appropriate when crafting speed policies for high-speed roadways.

## Overall Effects

Within the comprehensive framework described above, the overall safety effects associated with a speed limit change are determined by tracing its separate and inter-related effects on driver speed choice, crash rates, and the probabilities of different injury severity levels.

For example, considering that the crash rate itself increases slightly with a speed limit increase, the overall change in the fatal crash rate following a speed limit increase will be slightly higher than just the increase in the probability of a fatality when a crash occurs. Broadly speaking, however, the association between speed limit and injury severity dominates the overall relationship between speed limit and overall injury or fatality counts. Table 1 illustrates this point.

In both cases, a 10-mph speed limit increase is estimated to result in a 3-mph increase in average driving speed.

In the lower speed limit range (55 to 65 mph), data analyses suggest a 3.3% increase in the total number of crashes and a 24% increase in the probability that a crash results in a fatal injury. Together, these increases combine to a 28% increase in the number of fatalities following the speed limit increase.

**TABLE 1** Safety Effects Associated with a 10 mph Speed Limit Increase on High-Speed Roads

| Increase in Speed Limit (mph) | Change in Average Driving Speed (mph) | Change in Total Crash Count | Change in Probability of Fatal Injury | Total Change in Fatal Injury Count |
|---|---|---|---|---|
| 55 to 65 | +3 | +3.3% | +24% | +28% |
| 65 to 75 | +3 | +0.64% | +12% | +13% |

NOTE: Calculations assume average high-speed roadway geometry.

In the higher speed limit range (65 to 75 mph), on the other hand, the increase in the total number of crashes is considerably smaller (0.64%). This is an illustration of the concave relationship between crash rate and speed limit described above. Although the statistical analysis does not provide an explanation for the form of this relationship, it may be that drivers are naturally more cautious at higher speeds or that the roads deemed suitable for 75-mph speed limits are intrinsically safer, so that the crash rate effect of increasing speed limits to this level is attenuated. For this speed limit increase, the predicted increase in the probability of a fatality in a crash is 12%, again lower than for the 55- to 65-mph speed limit increase. Explanations similar to those suggested above may apply here as well. The overall effect of these increases is a 13% increase in total fatalities, which is slightly less than one-half the fatality increase predicted for a 55- to 65-mph speed limit increase. The explanations for this smaller overall increase follow directly from those for the individual effects that contribute to it.

Predictions of injury severity distribution changes following speed limit changes, such as those mentioned above, require the application of both speed choice models and injury severity models. The crash severity models were based on cross-sectional data and, as was discussed above, may overestimate the speed change effect by a factor of roughly 2 when compared with the results of actual before-after studies on individual roadways, implying that the predictions of injury severity changes following a speed limit change may be based on travel speed differences that are themselves too high. This could result in an overestimate of the injury severity effect, perhaps by a factor of more than 2. Nonetheless, even after allowing for such effects, the relationship between typical speed limit changes on high-speed roads and the injury severity distribution would, in many cases, remain statistically and practically significant.

Some (but by no means all) studies have found significant increases in fatality rates on high-speed roads following the 1987 NMSL relaxation from 55 to 65 mph on rural interstates. Fatality rate increases in the range of 30 to 57% have been reported, using aggregate data. The corresponding prediction of the HSIS-based model is 24% for a "typical" high-speed roadway. Strictly speaking, these values cannot validly be compared; nonetheless, it is striking that the research result, although slightly lower, is in the same general range as the values found by these other studies. Although this is not a validation of the HSIS-based model, it is fair to say that its predictions are roughly consistent with the overall NMSL relaxation fatality effects found by some researchers, using more aggregate datasets and statistical methods less able to account for their specific characteristics. The research team's results, however, provide considerably more insight into the various effects of speed limit changes on speed, crash probability, and the injury severity distribution following a crash.

## Secondary Effects

It is sometimes argued that changes in the speed limit on one road or road class may affect the distribution of traffic across other roads and road classes, from driver reactions either to the speed limit change itself or to the associated enforcement activities (if any).

The data available to this study did not allow a systematic investigation of these potential secondary effects of speed limit changes. An analysis of these effects, at the disaggregate level pursued throughout the work, would require a detailed set of traffic volume, speed, and crash data extending across all road types (including non-high-speed roads) likely to be affected by driver reactions to a speed limit change. Such a dataset was not available.

Nonetheless, two comments can be made regarding secondary effects. First, a before-after analysis conducted at four sites in Washington State suggested that the average speed effects of a speed limit change were confined to the roadways on which the changes occurred. Two of the sites were on roadways that experienced 5-mph speed limit changes; statistically significant changes in average speeds were observed at these sites, but not at nearby sites that did not experience speed limit changes. This suggests that, in this case at least, secondary effects on speeds (and perhaps volumes) were not significant.

Second, interviews conducted with state DOT and police officials regarding enforcement policy changes following the NMSL repeal suggest that any such changes were, at most, limited in extent and geographic scope. Thus, it appears to be unlikely that driver route choice behavior was affected in a systematic and large-scale way by changes in traffic safety enforcement practices following the NMSL repeal, and so these secondary effects might be minor.

## NON-SAFETY IMPACTS OF SPEED LIMIT CHANGES

The investigation of non-safety impacts of speed limit changes relied on published literature, unpublished reports by state DOTs, and results of surveys of state DOT and police officials. This investigation was a lower-priority project effort than the analysis of safety impacts discussed above.

### Economic Impacts

In broad terms, non-safety impacts of speed limit changes may include effects on economic, environmental, and/or commercial conditions. Unfortunately, generally applicable conclusions regarding such effects are mostly lacking.

Speed limit increases translate into less-than-equivalent increases in average travel speed. The reduced travel times made possible by higher travel speeds have an economic value. However, when considering the systemwide effects of a speed limit change, it must be remembered that, in general, not all travel will be fully affected by the change. For example, travel for which average speeds are significantly constrained by congestion will likely not experience the full effects of a speed limit change.

Changes in average travel speed also affect vehicle operating costs. Of the various cost components that contribute to overall operating costs, running costs (those that directly result from vehicle operation) are most significantly affected by speed; and, of running cost components, fuel consumption costs are the largest portion. Under typical operating conditions on high-speed roads, a 10-mph speed limit increase would lead to an operating cost increase of roughly one-half the value of the travel-time savings, further reducing the net economic benefit from higher speeds.

### Other Impacts

With respect to the noise and air quality impacts of speed limit changes, the little evidence available suggests that these are small to negligible.

The project was unable to find any empirical or documentary evidence regarding possible commercial impacts of speed limit increases. The resulting (smaller) increases in average speeds of commercial vehicles should, in the medium to long term, result in opportunities for more efficient transportation and business operations. However, such speed changes are typically small, and the productivity of a commercial vehicle (and of the operations that it serves) depends only partly on its travel speed since it may spend significant time in loading/unloading operations or waiting for cargo. Thus, the effects on business and commerce of speed limit changes are likely to be marginal.

## ENFORCEMENT POLICY RESPONSES TO THE NMSL AND ITS REPEAL

The project conducted surveys of state DOTs and police agencies to identify enforcement policy responses to the NMSL and its repeal.

It is sometimes claimed that the NMSL imposition and related federal mandates led to a systematic concentration of speed limit enforcement efforts on high-speed roads, to the detriment of potentially more beneficial traffic enforcement efforts of other kinds or on other facility types. Available data from DOTs and state police agencies did not allow a rigorous investigation of this assertion. Nonetheless, anecdotal evidence collected by the project through surveys of state DOT and police officials across the country suggests that neither of these things happened systematically or on a large scale.

Some respondents acknowledged that there was a concern in their agencies to demonstrate compliance with the NMSL in order to avoid federal sanctions. However, respondents were adamant that no enforcement actions taken during the period of the NMSL were of a nature to compromise traffic safety. Similarly, respondents cited no examples of systematic changes in enforcement practices away from speed limit enforcement on high-speed roads following the NMSL repeal. Indeed, several respondents and DOT reports noted that speed limit enforcement activities actually became *more* intensive on high-speed roads in the period following the repeal.

The evidence suggests that the response of most police agencies to the NMSL relaxation and repeal generally took more measured forms: for example, reduced tolerance for speeds higher than the new limits together with, in some cases, a new speeding fine structure and/or an aggressive information campaign to notify the public of the tougher post-repeal policy.

## DATA RECOMMENDATIONS

The methods used in this work were guided, and limited, by the extent and quality of existing datasets. For example, Washington State's HSIS dataset is thought to be the best that the United States offers, but its panel datasets are missing key years (1997 and 1998). The dual-loop detectors in Washington State's northwest region were originally thought to provide speed averages at 30-sec intervals, but it was found that the original detailed data had been lost through aggregation to 5-min intervals.

Although the characteristics of the available data frequently constrained the types of analyses that the project could perform, the datasets assembled and used by the project were typically of a quality higher than (and at least comparable to) those generally available elsewhere in the United States and abroad. Thus, the data limitations present in the project datasets are likely also to be present in all but very specialized and focused traffic and crash datasets available elsewhere. Broadly speaking, datasets covering extensive geographic areas are likely to be less detailed, while those that include very detailed data are likely to focus on relatively limited geographic areas, highway facilities, and/or time periods.

The ideal dataset for traffic safety research purposes would offer true counts and speeds, fully integrated data on design, operations, and crashes for a wide range of sites (on the order of at least 500 centerline miles, rural, and urban), over several years, both before and after speed limit changes. Exposure vehicle miles traveled (VMT) would be accurately estimated, rather than derived from very imprecise estimates of annual average daily travel (AADT) based on a sparse set of periodic (i.e., occasional) short-term traffic counts, as is frequently the case.

Toward this goal, the project has recommendations regarding future data collection efforts to support fundamental research into crash causality and characteristics, but these recommendations are conditioned by the considerations expressed above. Research-oriented data collection efforts should, as much as possible, complement and build on the crash, traffic, and highway inventory data collection efforts routinely carried out. Given these sources of currently available data, it is worthwhile to focus research-oriented data collection in a few specific ways. These recommendations echo and parallel those of a recent government review of the National Highway Traffic Safety Administration (NHTSA) grant program that helps states improve their safety data systems (Government Accountability Office, 2004).

First, traffic safety research would benefit from the collection and assembly of additional *types* of information on the characteristics of roadways and their environments. This could include information on pavement and weather conditions; the presence and nature of embankments, barriers, and culverts; driveway and cross-road frequencies; clear zone width; and sight distances. None of the datasets that the project analyzed contained such data. As explained in Chapter 4 of the contractor's final report, available as part of *NCHRP Web-Only Document 90,* one of the analytical difficulties that had to be confronted was the potential for correlations between speed limits and unobserved roadway and environmental characteristics such as these. As discussed in the report, such correlations can bias speed limit impact estimates by attributing to speed limits some of the effects that are actually due to the unobserved characteristics. A dataset containing such data could considerably reduce this difficulty by allowing the effects of these characteristics to be estimated explicitly. However, this work's analysis of crash rate changes resulted in estimates similar to those arising from an analysis of counts, suggesting that this issue may not lead to practically different conclusions.

Second, it would be more efficient to concentrate near-term research-oriented data collection efforts on a subsystem of the overall highway system. This would ideally be a subset for which some of the required research-related traffic safety data already exists in some form and for which the remainder can be expeditiously collected and processed. The high-speed roadway subsystem would seem to be a good initial candidate in this regard. Over the longer term, it would be desirable to extend such data collection efforts to other components of the overall system.

The number of urban areas deploying high-performance traffic sensor systems continues to increase. Such instrumentation and the associated data processing systems can be used to support freeway and/or arterial management systems, incident response systems, and advanced traveler information systems (ATIS), among other uses. The data generated by these traffic measurement systems is frequently preserved and stored; indeed, the ongoing federally sponsored Archived Data User Service (ADUS) represents a national significant effort to standardize and make available traffic and operations data from traffic sensor systems and other ITS components around the country.

The project examined most of the metropolitan areas with currently operational traffic sensor systems as possible sources of data for its analyses and model development activities. For various reasons, the data from most of the examined systems was found to be unsuitable for project use. Some systems, for example, only covered a relatively small length of roadway, so that the number of crashes occurring on them would be too small to constitute a statistically valid sample. Others aggregated the archived traffic data into time intervals that were too long to be useful for the project's disaggregate analysis of traffic characteristics. In those cases where the data could have been used by the project, assembling and integrating the disparate sources of required data (i.e., highway inventory, traffic, and crash data) exceeded the resources available to the project. However, it is likely that, over time, local agencies will find it advantageous to develop and maintain such integrated datasets themselves, and as this happens these will become an increasingly valuable and accessible source of data for traffic safety research.

Toward this end, data-producing agencies should be encouraged to adopt consistent geo- or linear referencing systems to facilitate the assembly of integrated sets of disparate data types. Furthermore, agencies should be encouraged to preserve collected data in the most disaggregate form feasible, rather than aggregating it in order to reduce its archiving costs. The declining costs of data storage should make this option more attractive to agencies' data services.

## CONCLUSIONS

The NMSL was adopted in 1974 in response to the first energy crisis. Its adoption, together with its relaxation on rural interstate highways in 1987 and its complete repeal in 1995, created the conditions for a unique large-scale natural experiment on speed limits and their safety and other effects. It is not likely that our nation will have another occasion to experience speed limit changes on such a broad scale in the foreseeable future.

It is clear that the more dire predictions made about the likely safety effects of the NMSL relaxation and repeal have not come to pass. Although some researchers have found significant changes in the crash experience of roadways that underwent speed limit changes, others have not, and it is fair to say that a broad consensus as to the effects of the speed limit changes still has not emerged. This suggests that, at an aggregate level, the overall magnitude of such effects, if indeed they exist, is as small as or smaller than those of changes in a wide variety of other safety-related factors that were occurring at the same time as, but (mostly) independently, of the speed limit changes themselves. Such changes include, among others

- Variability in weather conditions;
- Improvements in roadway design;
- Changes in DUI and young driver laws;
- Changes in traffic police practices and policies;
- Changes in drivers' seatbelt use habits;
- More effective driver education and public traffic safety awareness programs;
- Demographic shifts in the driving population, including driver ages and gender distributions;
- Changes in driving patterns, including the distribution of travel between day and night hours, urban and rural locations, and interstate and other facility types;
- Improved safety features in vehicle designs;
- Increases in VMT per lane mile of network capacity and increases in congestion;
- Increased use of in-vehicle communications devices (e.g., cellular telephones), leading to more rapid notification of and response to crash situations; and
- Improved capabilities and effectiveness of emergency response services.

The aggregate combined effects of these changes, together with whatever effects the speed limit increases themselves may have had, appear to have been small.

This project carried out much more detailed disaggregate-level analyses, however, and the conclusions that emerge from these are somewhat clearer.

Largely based on data collected in Washington State, the study found that small (roughly 3%) increases in total crash rates are associated with a speed limit increase from 55 to 65 mph on an "average" high-speed roadway section. A significant increase in the probability of fatalities and incapacitating injuries is associated with higher speed limits. For this particular 10 mph speed limit change, a 24% increase in the fatal injury probability would be expected. These predictions would be different for different roadway sections and speed limit changes.

Application of the cross-sectional models underlying these crash-severity predictions may tend to over-predict the effects of speed limit changes because actual changes in average travel speeds following changes in speed limits may be lower than those observed across a set of existing roadways with different speed limits. Nonetheless, even if actual speed changes are expected to be 50% lower than those implied by the cross-sectional models, their effect on the crash fatality rates (and more generally on the injury severity distribution) would, in many cases, remain statistically and practically significant.

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