Effects of Raising and Lowering Speed Limits on Selected Roadway Sections

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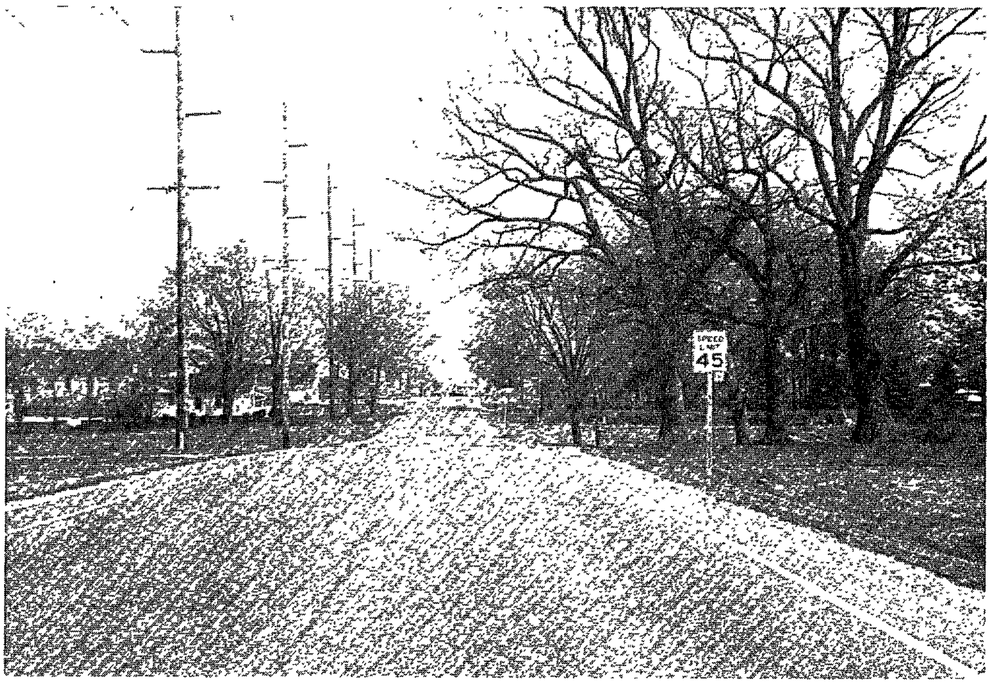

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Federal Highway Administration

Research and Development
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McLean, Virginia 22010-2296

FOREWORD

This report may be of interest to traffic engineers and policy makers responsible for making decisions involving the setting of speed limits on short segments on surface streets and highways in suburban and rural areas. The report results DO NOT involve changing speed limits on limited access highways (freeways). Measurements were also made on only four sections of Interstate highways and the results are presented in an appendix. The limited results of the freeway studies are an indication of the effects of raising the speed limit at the study sites only. Thus, use of the study findings should not be made in discussions about roadways that were formerly subject to the recently repealed National Maximum Speed Limit.

Because of the controversial nature of the subject of changing speed limits, and because the results are somewhat contrary to what many expect when speed limits are raised or lowered, the Transportation Research Board conducted a workshop at FHWA's request with this report as the primary resource paper. The purpose of the workshop was to get a thorough review of the methods of data collection and analyses to ensure that there are no questions as to the validity of the reported results. As recommended by the workshop participants, we are publishing this report with the few minor modifications identified. The changes dealt mostly with the following: removing the author's opinions that were not based on the research results, indicating why the initial experimental plan could not be followed, describing the three types of sites where speed limits were changed, doing an accident analysis based on accident rates to accommodate sites where traffic volumes had changed, and putting the freeway analysis in an appendix and noting that freeway data is much different than surface roadway site data in both speed changes and accident results. Also, the report title was changed to indicate that the sites studied were "selected roadway sections."

The reader should remember that this report addresses the observed behavior of a very large number of drivers operating under a wide variety of highway conditions and various speed limit scenarios. The report describes the results of one of the broadest speed behavior studies ever undertaken, and it is believed to offer valuable insight on the relationship of highway geometrics, speed limits, driver behavior, and highway accidents. The report should be considered as a resource document as opposed to a speed policy recommendation.

Sufficient copies of this report are being distributed to provide a minimum of two copies to each FHWA regional office and six copies to each Division office. Four of the Division office copies should be sent to their State highway agency by the division

A. George Ostensen, Director
Office of Safety and Traffic Operations
Research and Development

NOTICE

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16. Abstract

The objective of this research was to examine the effects of raising and lowering posted speed limits on driver behavior for urban and rural nonlimited access highways. Sites selected for study were furnished by the participating States. The study was conducted during the period from October 1985 to September 1992, when the maximum speed limit was 55 mi/h (89 km/h) on nonlimited access highways. During this period, the States and localities lowered and raised posted speed limits on short roadway segments, typically less than 2 mi (3.2 km) in length. The general types of sites included in the study were short sections, i.e., 0.5mi (0.8-km) segments in rural communities, I-mi (1.6-km) sections in urban and rural communities, and 2-to 12-mi (3-to 19-km) rural sections where speed limits were raised. The study included the collection of driver behavior and crash data in 22 States. The data were collected at 100 sites on nonlimited access highways, consisting of 172 mi (277 km) where speed limits were either lowered or raised, and at 83 comparison sites, consisting of 132 mi (213 km) where no changes in the posted speed limits were made. Changes in the posted speed limits ranged from lowering the speed limit by 5, IO, 15, or 20 mi/h (8, 16, 24, or 32 km/h) to raising the speed limit by 5, 10, or 15 mi/h (8, 16, or 24 km/h). Only one change in the posted speed limit was made at each site during the study.

There is statistically sufficient evidence in this dataset to reject the hypothesis that driver speeds do not change when posted speed limits are either raised or lowered. However, the differences in speeds, less than 1.5 mi/h (2.4 km/h), are not sufficiently large to be of practical significance, and are due primarily to large sample sizes. Although the changes in vehicle speeds were small, driver violations of the speed limits increased when posted speed limits were lowered. Conversely, violations decreased when speed limits were raised. This does not reflect a change in driver behavior, but a change in how compliance is measured, i.e., From the posted speed limit. There is not sufficient evidence in this dataset to reject the hypothesis that crash experience changed when posted speed limits were either lowered or raised.

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Mean speed, 85th percentile speed, headway, driver compliance, crash analysis	No restrictions. This document is available through the National Technical Information Service, Springfield, Virginia 22161.

19. Security Classif (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	175	

METRIC/ENGLISH CONVERSION FACTORS

ENGLISH TO METRIC

LENGTH (APPROXIMATE)

1 inch (in) = 2.5 centimeters (cm)
1 foot (ft) = 30 centimeters (cm)
1 yard (yd □ 0.9 meter (m)
1 mile (mi) = 1.6 kilometers (km)

AREA (APPROXIMATE)

1 square inch (sq in, in^2 = 6.5 square centimeters (cm^2)
1 square foot (sq ft, ft^2 = 0.09 square meter (m^2)
1 square yard (sq yd, yd^2) = 0.8 square meter (m^2)
1 square mile (sq mi, mi^2) = 2.6 square kilometers (km^2)
1 acre = 0.4 hectares (he) = 4,000 square meters (m^2)

MASS - WEIGHT (APPROXIMATE)

1 ounce (oz) = 28 grams (gr)
1 pound (lb) = .45 kilogram (kg)
1 short ton = 2,000 pounds (Lb) = 0.9 tonne (t)

VOLUME (APPROXIMATE)

1 teaspoon (tsp) = 5 milliliters (ml)
1 tablespoon (tbsp □ 15 milliliters (ml)
1 fluid ounce (fl oz) = 30 milliliters (ml)
1 cup (c) = 0.24 liter (l)
1 pint (pt) = 0.47 liter (l)
1 quart (qt) = 0.96 liter (l)
1 gallon (gal) = 3.8 liters (l)
1 cubic foot (cu ft, ft^3) = 0.03 cubic meter (m^3)
1 cubic yard (cu yd, yd^3) = 0.76 cubic meter (m^3)

TEMPERATURE (EXACT)

[(x-32)(5/9)] ^{o}F □ y ^{o}C

METRIC TO ENGLISH

LENGTH (APPROXIMATE)

1 millimeter (mm) = 0.04 inch (in)
1 centimeter (cm) = 0.4 inch (in)
1 meter (m) = 3.3 feet (ft)
1 meter (m) = 1.1 yards (yd)
1 kilometer (km) = 0.6 mile (mi)

AREA (APPROXIMATE)

1 square centimeter (cm^2) = 0.16 square inch (sq in, in^2)
1 square meter (m^2) = 1.2 square yards (sq yd, yd^2)
1 square kilometer (km^2) = 0.4 square mile (sq mi, mi^2)
1 hectare (he) = 10,000 square meters (m^2) = 2.5 acres

MASS - WEIGHT (APPROXIMATE)

1 gram (gr) = 0.036 ounce (oz)
1 kilogram (kg) = 2.2 pounds (lb)
1 tonne (t) = 1,000 kilograms (kg) = 1.1 short tons

VOLUME (APPROXIMATE)

1 milliliters (ml) □ 0.03 fluid ounce (fl oz)
1 liter (1) = 2.1 pints (pt)
1 liter (l) = 1.06 quarts (qt)
1 liter (l) = 0.26 gallon (gal)
1 cubic meter (m^3) = 36 cubic feet (cu ft, ft^3)
1 cubic meter (m^3) = 1.3 cubic yards (cu yd, yd^3)

TEMPERATURE (EXACT)

[(9/5) y + 32] ^{o}C □ x ^{o}F

QUICK INCH-CENTIMETER LENGTH CONVERSION

INCHES: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10

CENTIMETERS: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 25.40

QUICK FAHRENHEIT-CELSIUS TEMPERATURE CONVERSION

°F	-40°	-22°	-4°	14°	32°	50°	68°	86°	104°	122°	140°	158°	176°	194°	212°
°C	-40°	-30°	-20°	-10°	0°	10°	20°	30°	40°	50°	60°	70°	80°	90°	100°

For more exact and or other conversion factors, see NBS Miscellaneous Publication 286, Units of Weights and Measures. Price $2.50. SD Catalog No. Cl3 10286.

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INTRODUCTION

This study was conducted to examine driver behavior effects when posted speed limits are raised and lowered on nonlimited access urban and rural highways. In the event that altering the posted speed limits had an impact on traffic speeds, crash data were collected to examine the safety effects. While much research in recent years has focused on the effects of the 55- and 65-mi/h (89- and 105-km/h) speed limits on limited access high-speed facilities, this research concentrated on lower speed urban streets and rural highways that were posted between 20 and 55 mi/h (32 and 89 km/h).

A maximum speed limit is posted or set by statute on a highway to inform motorists of the highest speed considered to be safe and reasonable under favorable road, traffic, and weather conditions.

A review of early vehicle speed legislation in the United States suggests that speed regulations were established to improve public safety!] The rationale for government regulation of speed is based on the fact that unreasonable speed may cause damage or injury. Speed laws also provide a basis for punishing the unreasonable behavior of an individual driver.

Every State has a basic speed statute requiring drivers to operate their vehicles at a speed that is reasonable and prudent under existing conditions.[2] This law recognizes that the maximum safe speed varies due to traffic, roadway, weather, light, and other conditions, and places the responsibility of selecting a safe and reasonable speed on the driver.

Most traffic engineers believe that speed limits should be posted to reflect the maximum speed considered to be safe and reasonable by the majority of drivers using the roadway under favorable conditions.[3] Procedures used to set speed limits have evolved through years of experience and research. Most States and localities set maximum speed limits based on the results of an engineering and traffic investigation.

The 85th percentile speed is used as a major factor in selecting the appropriate speed limit for a street or highway; however, other factors, such as roadside development, crash experience, and design speed, are often considered.[3] While traffic engineers and enforcement officials consider a number of factors when determining the speed limit to post, public and political opinions can and do influence their decision.

There are a number of strongly held opinions by the public concerning the effects of a posted speed limit. One of the opinions often expressed is that setting low speed limits will reduce vehicle speeds and crashes. Also, it has been frequently suggested that most motorists drive 5 to IO mi/h (8 to 16 km/h) over the posted speed limit, so lower speed limits should be established to account for this condition.

Conversely, it is believed that raising the posted speed limit on nonlimited access highways increases vehicle speeds and crashes. For example, following a severe crash, one of the most frequent requests made to highway jurisdictions is to lower the speed limit. These requests are founded on public knowledge that crash severity increases with increasing vehicle speed, because in a collision, the amount of kinetic energy dissipated is proportional to the square of the velocity. Simply stated, when a vehicle is involved in a crash, the higher the vehicle speed, the greater the chance of being seriously injured or killed. However, as noted by a number of researchers, the potential for being involved in a crash is highest when traveling at a speed much lower or much higher than the majority of motorists.[4-7]

For years, traffic engineering texts have supported the conclusion that motorists ignore unreasonable speed limits.[8] Both formal research and informal operational observations conducted over many years indicate that there is very little change in the mean or 85th percentile speed as the result of raising or lowering the posted speed limit on urban and rural nonlimited access highways.[9]

Highway administrators, enforcement officials, the judiciary, and the public need factual information concerning the effects of posted speed limits on driver behavior for nonlimited access roadways. For example, will lowering the posted speed limit on a two-lane roadway section through a rural community reduce vehicle speeds? Does raising the posted speed limit to the 85th percentile speed on a short segment of roadway increase vehicle speeds? Do most motorists drive 5 to 10 mi/h (8 to 16 km/h) above the posted speed limit? What are the effects of lowering or raising speed limits on driver compliance?

OBJECTIVES AND SCOPE

The objective of this research was to determine the effects of raising and lowering speed limits on driver behavior for urban and rural nonlimited access highways. During the period the study was conducted, from October 1985 until September 1992, the maximum speed limit was 55 mi/h (89 km/h) on nonlimited access highways. During this time, the locations where States and localities raised and lowered posted speed limits were typically limited to roadway segments less than 2 mi (3.2 km) in length. Consequently, the sites selected for study were limited to roadway sections with an average site length of 1.7 mi (2.7 km).

Driver behavior effects examined in this study included the speed distribution (percentile speeds), mean speeds, speed variance, percent of drivers exceeding the posted speed limit, and close following behavior. Anticipating that changing the posted speed limit could have an effect on driver speeds, crash data were collected to examine the safety effects. The crash data included police-reported crashes, crashes involving injury or death, and multiple-vehicle and single-vehicle crashes.

It is important to emphasize that this research was limited to examining driver behavior effects as a result of changing the posted speed limit only. It is recognized that enforcement and public education are key components in making any traffic regulation effective, including speed limits. While highly visible enforcement is essential to detecting and deterring speeding motorists, and public educational campaigns can influence motorists' attitudes, this research did not examine these factors.

The scope of the study included the collection of driver behavior and crash data in 22 States, as shown in figure 1. The data were collected at 100 sites on nonlimited access highways, consisting of 172 mi (277 km) where speed limits were either raised or lowered, and at 83 comparison sites, consisting of 132 mi (213 km) where no changes in the posted speed limits were made.

Repeated speed measurements were made at 11 selected sites to examine the time effects of speed limit changes. Data were also collected at five sites that were contiguous to four experimental roads to determine if speed limit changes on the experimental sites had indirect effects on driver behavior on the contiguous sections.

In April 1987, at the end of the site-selection phase of the study, Congress permitted States to raise speed limits on selected limited access facilities to 65 mi/h (105 km/h). To obtain some information concerning the speed effects on these high-speed facilities, four sites consisting of 94 mi (151 km) were nonrandomly selected in three States. Due to the small sample size and the nonrandom selection of sites, the results of the speed and crash data collected at these sites are not included in the main section of the report, but are discussed in a separate appendix.

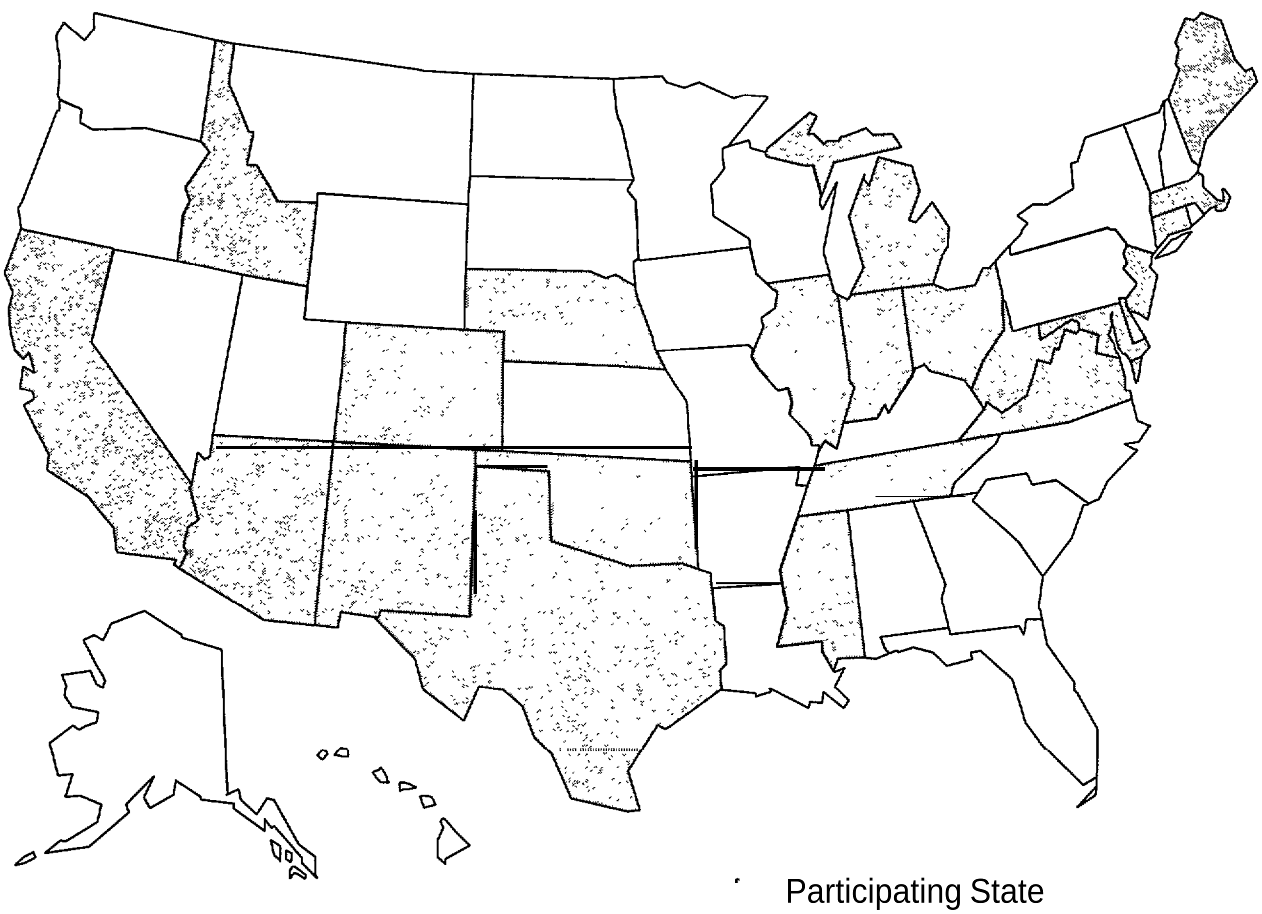


Figure 1. States participating in the study.

METHODOLOGY

Early in the development of the methodology for the study, the researchers proposed that a before-and-after with randomized control group experimental design be utilized to determine the effects of raising and lowering posted speed limits on driver behavior and crashes. With this design, roadway sections would be randomly drawn from the population of nonlimited access highways in the United States. The selected sections would then be randomly assigned to experimental and control groups. Posted speed limits on highways in the experimental group would either be raised or lowered. No changes in the posted speed limits would be made at the control sites.

Utilizing this experimental plan would reduce the major threats to internal and external validity, i.e., one would be able to generalize the findings to the population of nonlimited access roadways from which the sites were drawn.

It was recognized by the sponsor and the researchers that this experimental design would be extremely difficult, if not impossible, to implement. On late 1985, letters were sent to the 50 State transportation agencies requesting their participation in the experiment. Written responses and telephone conversations with agency personnel indicated that only three States had a limited interest in permitting the researchers to randomly select roadways for speed limit changes.

The major reasons cited by the States for not participating are listed below:

- By law, the States are responsible for setting speed limits on the basis of a traffic and engineering investigation. To raise or lower the speed limit on a randomly selected roadway section for research purposes would not meet the requirements of State and local statutes.

- The potential for tort liability resulting from changing the speed limit on a selected experimental section, where the decision to alter the limit was not based on an engineering investigation, was a major objection. Also, there were liability concerns for not changing the speed limit on a comparison section if an investigation indicated that the limit should be altered.

- There were concerns that the credibility and reputation of the transportation agency would be diminished if they allowed the researchers to select the sites for speed limit changes. The primary concern was that the speed limit change would be controversial or would not be supported by the public.

From the responses received, it was clear that the study could not be conducted as proposed. Members of the American Association of State Highway and Transportation Officials' (AASHTO) Subcommittee on Traffic Engineering were instrumental in assisting with the development of a realistic plan that would provide information on the effects of speed limit changes. Major considerations, provided by the AASHTO Subcommittee, that influenced the selection of the final plan are summarized on the following page:

- Experimental sections for the study would have to be drawn from roadways where speed limit changes were made by the agencies based on the results of a traffic and engineering investigation.

- During any given 12-month period, it was estimated that speed limits were altered on approximately 100 mi (161 km) of roadway in the United States.

- The average length of a section where speed limits were altered was 0.5 mi (0.8 km); however, some sections were 1mi (1.61 km) in length or greater.

- After the decision is made to change a speed limit on a roadway, the new limit is typically posted within a period ranging from 1 week to 1month. This time constraint would not permit the collection and analysis of speed, volume, and crash data needed to properly select and match comparison and experimental site characteristics.

- Due to the 55-mi/h (89-km/h) National Maximum Speed Limit in effect during the study, most posted speed limit changes occurred on short sections of nonlimited access facilities located in urban fringe, suburban areas, and small rural towns.

Because random selection and assignment of sites to experimental and comparison groups was not possible, the sponsoring agency and the researchers made a decision to select the experimental sites from roadway sections where State and local jurisdictions planned to make speed limit changes based on the results of routine traffic and engineering investigations.[10] The comparison sites were selected by the research team after the experimental sites were identified.

Speed limits on the experimental sites were either raised or lowered by the participating State or local highway agency for various reasons as listed below:

- As a result of a request from the public, political leaders, or enforcement officials.

- To ensure that speed limits were appropriate for roadway and traffic conditions.

- As a result of a high incidence of traffic crashes.

- To comply with local laws or ordinances.

- In response to changing traffic volume and land-use patterns.

Nonrandom selection and assignment of sites to experimental and comparison groups can produce biased results and limits the findings and conclusions only to the locations studied. The findings may apply to similar sites where the speed limits are changed for similar reasons. Generalizations to other roadways are not appropriate.

It is important to reiterate that speed limit changes at the study sites were not made for the purpose of experimentation. Consequently, the researchers were not involved in determining the speed limit change, nor was a study of an individual State's method of setting speed limits undertaken. All speed limit changes were reported to the public in the routine manner used by the State or local jurisdiction. To the author's knowledge, no special enforcement or public information campaigns were initiated after the new speed limit was posted at any of the study sites.

Selection of Experimental Sections

With the modified plan, 33 States formally agreed to participate in the study by notifying the researchers of nonlimited access roadway sections where they planned to make speed limit changes. Using input from the participating jurisdictions, experimental sites were selected during the period of May 1986 through April 1987. Experimental sites were selected based on the following considerations:

- Generally, sections less than 0.5 mi (0.8 km) in length were not selected. In some cases, however, the segment where the speed limit change occurred was shorter than originally proposed when the site was selected. Thus, the study includes some sites less than 0.5 mi (0.8 km) in length.

- Sections that were recently reconstructed or were subject to construction during the before or after study periods were not used.

- Sections were used when the only physical site changes during the study period were due to routine maintenance, such as repairing potholes, regrading shoulders, repainting center and edge lines, etc. In some cases, sections were included that received minor safety improvements such as replacing worn traffic signs with new signs. The pavement was resurfaced at four experimental sites after the speed limits were raised, and the speed effects at these locations are noted in a subsequent section of this report.

- Sections with more than one speed limit change during the study period were eliminated because the effects of multiple changes could confound the results.

- Sites were selected in States to represent a wide range of geographic and urban and rural conditions.

- Sites were selected to provide a mixture of typical locations where speed limits were either raised or lowered by the States and local jurisdictions during the time period the study was conducted.

- Time constraints played a role in the selection of some sites. As previously mentioned, the time period between notification of an available site and the time the new speed limit was scheduled to be posted varied between 1 week and 1 month. Some sites were not selected for study because there was insufficient time for the data collection crews to complete their current assignment and travel to the next site before the new speed limit was posted.

Approximately 20 percent of the sites submitted by the States and jurisdictions were actually selected for the study. The predominate reasons for not selecting sites were that the sections were less than 0.5 mi (0.8 km) in length, and major construction or safety improvements were made or planned at the sites either during the before or after study periods.

The experimental plan for the study called for a minimum of 100 mi (161 km) each of experimental and comparison sections based on estimated fatal and injury crash counts.[10] As sites were selected, it became clear that the crash counts on the sections were lower than estimated, thus the final sample was increased to contain 172 mi (277 km) of experimental sites and 132 mi (213 km) of comparison sites.

The experimental sites on nonlimited access highways included in the study can be categorized into three basic groups:

1. A roadway section in a small rural town or community where the speed limit on the adjoining roadway sections was 55 mi/h (89 km/h). Typically, the length of these sections varied between 0.5 and 1 mi (0.81 and 1.61 km). The speed limit on these roadways was usually lowered, but in some cases, the limit was raised.

2. A roadway section in an urban, suburban, or rural area where public or political requests or increases or decreases in the adjacent land use and corresponding traffic volumes dictated the need for a change in the speed limit. These sections were typically 1 mi (1.61 km) in length. The speed limit on some of these roadways was raised, but was lowered at other sites.

3. A two- or four-lane nonlimited access roadway section in a rural area where the speed limit was raised to 55 mi/h (89 km/h). These sections were generally between 2 and 12 mi (3.2 and 19.3 km) in length.

Shown in figure 2 is a roadway section in a small rural community where the speed limit was lowered from 55 mi/h to 45 mi/h (89 km/h to 72 km/h). The roadway section is 0.52 mi (0.84 km) in length, and the speed limit on the adjoining sections is 55 mi/h (89 km/h).

Shown in figure 3 is a typical roadway in a small urban area where the speed limit was lowered from 35 to 25 mi/h (56 to 40 km/h). The section is 0.74 mi (1.2 km) in length. Speed limits on the adjoining sections are 25 and 35 mi/h (40 and 56 km/h).

Depicted in figure 4 is a rural location where the speed limit was raised from 50 to 55 mi/h (81 to 89 km/h). The roadway segment is 7.33 mi (11.8 km) in length. The speed limit was raised as a result of a routine review of speed limits.

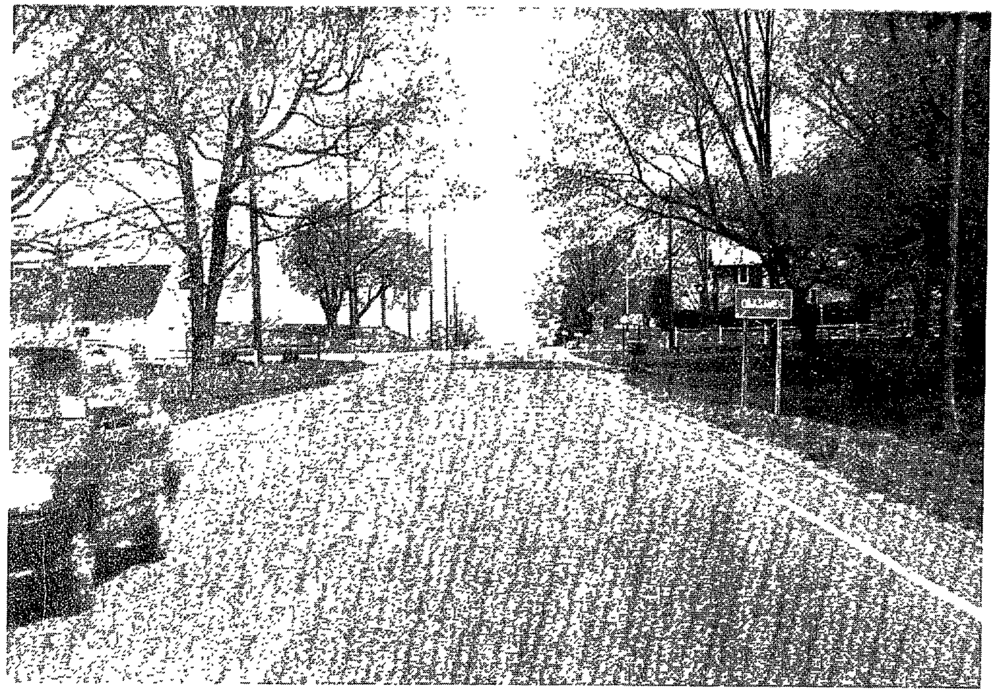


Figure 2. Roadway in rural community where the speed limit was lowered.

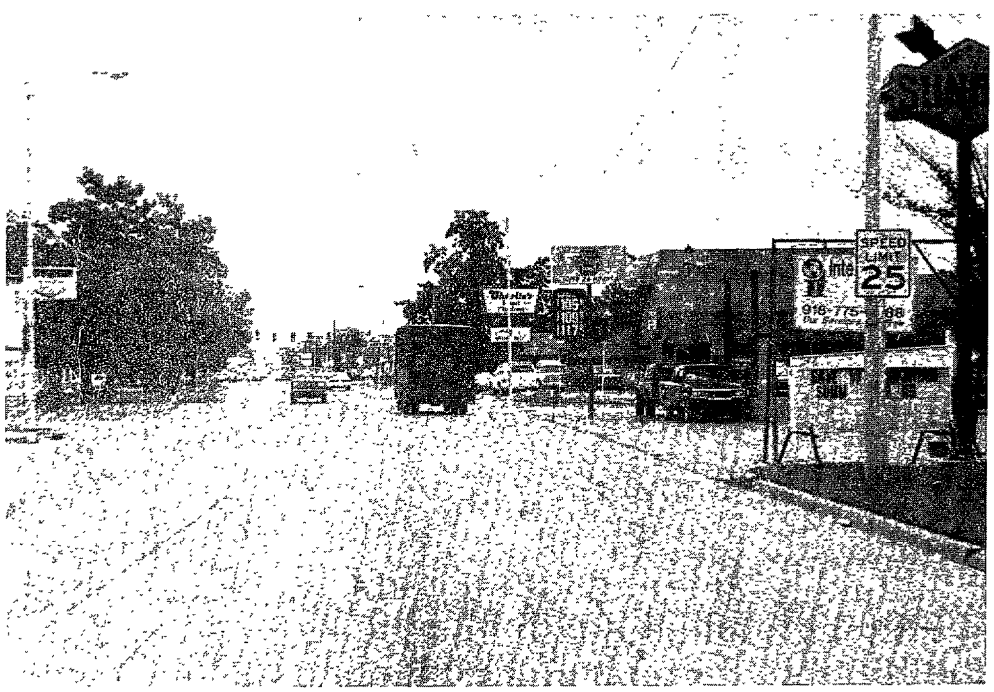


Figure 3. Roadway in urban area where the speed limit was lowered.

Figure 4. Roadway in rural area where the speed limit was raised.

Selection of Comparison Sections

As previously mentioned, comparison sites were not randomly drawn from the population of nonlimited access facilities or from the same source that produced the experimental sites (i.e., sites studied by the highway agencies for speed limit revisions). Although attempts were made, it was not usually possible to obtain timely information on segments that were studied for speed limit revisions, but where no speed limit changes were made. Consequently, comparison sites were selected by the research team during their field review of the experimental sites.

Although the comparison sites were not drawn from the same source as the experimental sites, the researchers decided that it was important to select comparison sites and to collect speed data at these locations in an attempt to control for factors such as weather, special events in the area, and other similar conditions that can affect driver behavior. The basic premise used to make this decision was that large before and after speed differences would be found at the experimental sites.

Guidelines for selecting comparison sites were based on matching, as closely as possible, the geometric, volume, and speed characteristics of the experimental sites. The matching process, although imprecise because data could not be collected in advance of site selection, was used in an attempt to find comparison locations with operational and safety characteristics that were similar to the experimental sites. For example, if the experimental site was a two-lane roadway carrying 2,000 vehicles per day, the research team would attempt to select another two-lane roadway in the jurisdiction with similar volume and speed characteristics.

Although efforts were made to find locations with the same posted speed limit, the comparison site did not always have the same posted speed limit as the experimental site. Also, it was not always possible to find a comparison site in the jurisdiction that exactly matched the volume and speed characteristics of the experimental site. In each case, however, the experimental and comparison site pair have the same number of lanes. Most comparison sections were located within 5 mi (8 km) of the experimental sites.

In some cases, for economic efficiency, one comparison site was matched with two similar experimental sites. At three locations, speed limit changes were made at the comparison sites after the before data were collected. These segments were then reclassified as experimental sections. In one case, the speed limit was not changed on the experimental section, but the agency changed the speed limit on the comparison section. The two sections were renamed and used in the study.

Data Collection

Before data were collected at 123 experimental sites and 114 comparison sites by 3 two-person data collection teams. Some sections were eliminated from the study because the planned speed limit alterations were not made, or road and/or utility construction was in progress. At one site in Maryland, two sites in Mississippi, and one site in Tennessee, the roadway on the experimental section was resurfaced after the before data were collected. Instead of eliminating these segments from the study, it was decided to collect after data at these locations to examine the speed changes. The results are presented in a subsequent section of this report.

When the data collection phase of the study was completed, before and after data were collected on 100 experimental sections consisting of 172 mi (277 km) and 83 comparison locations totaling 132 mi (213 km). Complete speed and headway data were available for 98 experimental sites and their corresponding comparison sites. The termini of two experimental sites were incorrectly given, thus speed data were taken at the wrong locations. These data are not used in the subsequent analysis of speed effects. Crash data were available for 99 experimental locations and their corresponding comparison sites. One locality could not provide crash data for a site located in their jurisdiction.

The speed limits on the experimental sections were changed between July 1986 and May 1989. Collection of the before data ranged from several days to 2 years prior to the speed limit change. Similarly, collection of the after data ranged from several days to as much as 2 years following the speed limit change. The before data were collected between June 1986 and June 1988. The after data were collected between August 1987 and July 1989.

Selection of Free-Flow Vehicles

One of the basic premises of posting speed limits is to influence driver behavior. Most States and localities measure speeds for setting speed limits based on selecting the speed of free-flow or unimpeded vehicles. The rationale for this procedure is that drivers who are in a platoon have their speed and maneuverability influenced by other vehicles and are not free to select their speed based on geometry, traffic control (which includes posted speed limits), and prevailing environmental conditions. Accordingly, if speed limits affect driving behavior, free-flow drivers are most likely to be influenced by speed limit changes. In an attempt to measure the speeds of free-flow vehicles, it was necessary to select a method to measure free-flow behavior.

The determination of impeded vs. unimpeded vehicles is a complex issue that has not been fully investigated. A minimum headway criterion is typically used to identify free-flow vehicles. A review of the literature indicated that free flow has been defined as having a minimum headway between vehicles of 3 to 9 s.[11-13] The most commonly used minimum headway values in practice and in research studies were between 4 and 6s.

In preparing to collect data for this study, it was decided to use a 4-s or greater headway, based on research conducted by Hanscom and others.[14,15] Hanscom found that the mean speeds of platoon leaders and following vehicles in the platoon were significantly different for a headway time of 4 s or greater. In other words, when the platoon leader begins to pull away from the following vehicle, the structure of the platoon is no longer maintained.

Examination of the before data collected at the experimental sites in this study revealed that an average of 82 percent of the vehicles sampled had a headway of 4 s or greater and 76.5 percent of the vehicles had a headway of 6 s or greater. The difference is 5.5 percent. In other words, if a 6-s definition of free flow would have been used instead of a 4-s definition, only 5.5 percent fewer vehicles would have been used in the analysis.

As headway is a function of traffic flow, there is considerable variation in the average values mentioned. At a low-volume site (24-h volume of 318 vehicles), 2.5 percent of the vehicles had a headway of less than 4 s and 3.1 percent of the vehicles had a headway of less than 6 s. At a high-volume site (24-h volume of 19,024 vehicles), 37.7 percent of the vehicles had a headway of less than 4 s and 49.8 percent of the vehicles had a headway of less than 6 s.

Regardless of which minimum headway criterion is selected, it is possible that situations occurred where headways were greater than 4 or 6 s, but vehicle speeds were impeded. For example, under heavy flow conditions, drivers may choose not to adjust their speed. Also, the platoon leader may just be driving slowly. Within the scope of the study and the equipment used, there was no method available to detect these conditions or to ensure that all vehicles with a headway of 4 s or more were unimpeded.

Because the speed and headway data were collected by automated equipment in bins, it is not possible to reanalyze the data using a 6-s or any other headway criterion. Consequently, it is unknown whether a 6-s headway would have made a difference in the before and after speed data presented in this report.

While the speeds of all vehicles were measured, only the speeds of free-flow vehicles having a headway of 4 s or more were used in the analyses presented in this report. An examination of the all-vehicle speeds vs. free-flow speeds indicated that free-flow speeds at the study sites were normally less than 2 mi/h (3 km/h) higher than the all-vehicle speeds.

Speed and Headway Data Collection

Volume, speed, and headway data were collected for a 24-h period simultaneously at each experimental and comparison site pair. The data were collected prior to the speed limit change on the experimental section, and again after the change was made. In most cases, the after data were collected in the same season and on the same weekday period as the before data. Data were collected during weekday and weekend periods, except no data were collected the day before, during, or after a holiday. At selected sites, multiple measurements were taken to examine seasonal and other effects. The speeds and headways of approximately 1.6 million vehicles were collected during the study.

The volume, speed, and headway data were collected with Sarasota VC1 900 automated roadside units.[16] Due to the memory limitations of the equipment, the data were recorded in 2-h increments for a 24-h period. The units were programmed to collect free-flow vehicle speeds by direction of travel and for two vehicle-length categories. Vehicles with a length of less than 20 ft (6.1 m) were classified as short vehicles. Vehicles 20 ft (6.1 m) in length or longer were classified as long vehicles. For each vehicle length, the equipment classified free-flow vehicle speeds in 1-mi/h (1.6-km/h) bins from 1 to 128 mi/h (1.6 to 206 km/h). The accuracy of the equipment for speed measurement was 0.5 mi/h (0.8 km/h), and the accuracy for length measurement was 1.5 ft (0.5 m).[16] A field check of the accuracy of the equipment was made during each data collection session with either a stopwatch using a defined distance or a vehicle with a calibrated speedometer.

Headway data were collected in 11 bins. Data in the first bin included the number of vehicles with headways of less than 2 s; the second bin included the number of vehicles with headways ranging from 2.00 to 2.99 s, etc. The 1 Ith bin included the number of vehicles with headways of 11 s or more. The accuracy of the equipment for headway measurement was 0.5 s.[16]

The data were collected for both directions of travel at a point representative of typical conditions on the roadway section. At most sites, the data collection points were located on tangent, level sections. Shown in figure 5 is a data collection setup showing the inductive loop mats in the roadway and the roadside units chained to a utility pole.

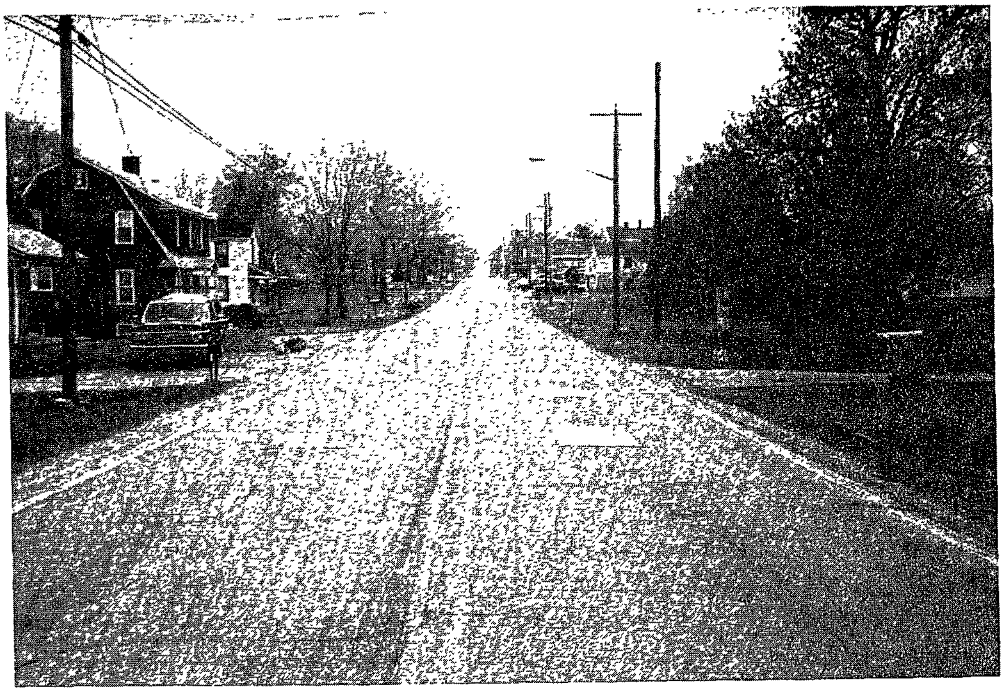


Figure 5. Typical field data collection setup.

Two inductive loop mats were deployed in the center of each lane at each site to detect vehicle speeds and one loop mat was deployed in each lane to collect headway data. For speed data collection, 3- by 6-ft (0.9- by 1.8-m) inductive loop mats were placed at a distance of 10 ft (3 m) from leading edge to leading edge. Temporary inductive loop mats were used as sensors to differentiate speeds by vehicle length.

Before and after data were collected at the same point on the roadway to permit comparisons and eliminate locational differences. Data were not collected near major intersections, driveways, or other features that would atypically affect normal driving speeds. Every attempt was made to conceal the roadside units and to make the sensors as inconspicuous as possible.

The data were extracted from the roadside units with a laptop computer and stored on diskettes. A computer program, written especially for the study, was used to summarize the speed and headway data for analysis. At each site, the free-flow speed data were summarized for short vehicles (less than 20 ft (6.1 m) in length), long vehicles (20 ft (6.1 m) in length or greater), and for both vehicle lengths combined. A sample printout of the 24-h speed data for all free-flow vehicles with both vehicle lengths combined is shown in table 1.

The two-person data collection teams also recorded geometric and roadway features such as the number of lanes, lane width, number of public streets, number of commercial and residential driveways, and number of speed limit signs.

Table 1. Sample of 24-h free-flow speed data collected at a site.

SITE NUMBER - OK03EB | AREA AND ROAD TYPE - Small Urban Two-Lane

STATE - Oklahoma | JURISDICTION - City of Sallisaw

ROUTE - 59 (Wheeler Avenue) | DIRECTION - Northbound and Southbound | CHANNEL NUMBER - 1 and 2

SPEED LIMIT - 35 mi/h | FREE-FLOW GAP = > 4 Seconds | LONG VEHICLE LENGTH = > 20 Feet

BEGINNING DATE -August 26, 1986 | RECORDING INTERVAL - 2 Hours

SUMMARY FOR ALL VEHICLE LENGTHS COMBINED

END TIME PERIOD	MEAN SPEED mi/h	STD DEV mi/h	TOTAL VOL.	FREE-FLOW VOL.	PCT. FREE FLOW	PERCENTILE SPEEDS mi/h 1	5	10	15	25	35	50	65	75	85	90	95	99	PERCENT EXCEEDING SPEED LIMIT BY (mi/h) 0	5	10	15	20	10-mi/h PACE LL	UL	PCT.	SKEW. INDEX
1300	39.5	6.2	729		80.6	25	29	32	34	36	38	40	42	44	46	48	50	55	78.4	44.8	18.7	4.4	0.8	35	44	62.0	1.00
1500	39.5	6.0	763	626	82.0	22	29	33	35	37	39	40	42	44	45	47	49	53	81.6	48.6	14.4	3.8	0.2	36	45	67.3	0.89
1700	38.8	6.2	972	742	76.3	23	28	31	33	35	37	40	42	43	46	47	49	52	74.9	43.1	15.5	2.6	0.3	34	43	59.6	0.89
1900	39.5	5.8	898	711	79.2	24	31	33	35	36	38	40	42	44	46	47	49	53	80.3	47.0	18.0	3.1	0.4	35	44	64.0	0.94
2100	39.2	5.6	542	468	86.3	26	31	33	34	36	38	40	42	43	48	47	49	52	78.2	44.4	15.2	2.8	0.6	34	43	65.0	1.00
2300	38.9	5.6	388	343	88.9	25	31	33	34	36	37	39	41	43	45	47	49	53	75.2	40.5	14.6	2.3	0.0	35	44	65.3	1.06
100	39.7	6.0	147	139	94.6	23	30	33	35	36	38	40	42	43	46	47	50	56	84.2	46.0	16.5	3.6	1.4	36	45	67.6	0.94
300	40.4	6.6	51	51	100.0	31	32	32	33	35	38	40	43	44	49	50	50	54	72.5	47.1	23.5	5.9	0.0	35	44	56.9	1.11
500	37.9	5.6	58	53	91.4	23	31	32	33	35	36	37	39	42	45	47	48	50	71.7	28.3	15.1	0.0	0.0	31	40	67.9	1.25
700	39.2	6.1	275	249	90.5	23	28	32	34	36	38	40	42	43	45	48	50	54	78.7	43.0	14.9	4.4	0.4	35	44	66.3	0.90
900	39.6	5.6	796	603	75.8	25	30	33	35	36	38	40	42	44	46	47	49	52	81.3	48.6	15.8	2.8	0.3	36	45	65.5	1.00
1100	38.9	6.2	668	551	82.7	24	28	31	33	36	37	39	42	43	46	48	49	53	75.7	43.6	16.7	1.6	0.9	35	44	60.4	0.95
TOTALS																											
PERIODS 12	39.3	6.0	6,283	5,125	81.6	24	29	32	34	36	38	40	42	43	46	47	49	54	78.4	45.1	16.2	3.1	0.5	35	44	63.0	0.94

1 ft = 0.31 m
1 mi/h = 1.61 km/h

Crash Data Collection

The crash data base for this study contains 6,307 police-reported crashes from 22 States. For most sections, crash data were available for a 3-yr period before the speed limit was changed and for a 2-yr after period. The participating transportation agencies furnished the data in a variety of formats, including copies of the crash reports, computer summaries, and individual crash listings.

The original crash data from each jurisdiction were encoded in the format received using dBASE IV, then summarized in a compatible format for analysis. The variables coded for each crash include site number, date, day of week, hour, severity (i.e., fatal crash, injury crash, or property damage only crash), the number of persons injured and killed, type of collision, number of vehicles, lighting and roadway surface conditions, intersection relatedness, and estimated vehicle speed (when speeds were recorded on the crash report). Other crash variables, such as contributing circumstance, were not collected because they were either not available or not consistently reported.

A sample printout of the crash data that were collected and summarized at a site is shown in table 2.

Table 2. Sample of crash data collected at a site.

Site Number	Crash Date	Day of Week	Hour	Crash Severity	No. Inj.	No. Fatal	Crash Type	No. Veh.	Light Cond.	Road Surface Cond.	Int. Related	Estimated Speed, mi/h Veh. 1	Veh. 2	Veh. 3
AZ01 E	10/25/84	Thu	15	Injury	3	0	Head-on	2	Day	Dry	Yes	30	15	NA
AZ01 E	06/15/65	Sat	7	Injury	3	0	Head-on	2	Day	Dry	No	50	25	NA
AZ01 E	06/19/85	Wed	10	injury	1	0	Other	2	Day	Dry	No	NS	35	NA
AZ01 E	06/1 9/85	Wed	16	PDO	0	0	Angle	2	Day	Dry	Yes	15	37	NA
AZ01 E	11/16/85	Sat	16	PDO	0	0	Angle	2	Day	Dry	No	3	35	NA
AZ01 E	11 /24/86	Mon	a	PDO	0	0	Rear-end	2	Day	Dry	Yes	20	2	NA
AZ01 E	03/24/87	Tue	18	PDO	0	0	Ran-off-road	1	Dusk	Other	Yes	54	NA	NA
AZ01 E	05/1 1 /87	Mon	16	PDO	0	0	Rear-end	3	Day	Dry	Yes	40	15	45
AZ01E	12/15/87	Tue	10	Injury	1	0	Rear-end	2	Day	Dry	Yes	40	5	NA
AZ01 E	03/17/88	Thu	17	Injury	1	0	Angle	2	Day	Dry	Yes	40	15	NA
AZ01 E	03/31/88	Thu	Ia	PDO	0	0	Other	1	Dusk	Dry	No	40	NA	NA
AZ01 E	07/14/88	Thu	23	PDO	0	0	Fixed-object	1	Dark	Dry	No	40	NA	NA
AZ01 E	11 /28/88	Mon	6	Injury	3	0	Rear-end	4	Day	Dry	Yes	28	0	0
AZ01 E	01/12/89	Thu	6	PDO	0	0	Rear-end	2	Dark	Dry	Yes	45	0	NA
AZ01 E	02/18/89	Sat	20	Injury	1	0	Angle	2	Dark	Dry	Yes	45	10	NA
AZ01 E	03/28/89	Tue	6	Injury	2	0	Ran-off-road	1	Day	Dry	No	40	NA	NA
AZ01 E	04/01/89	Sat	10	PDO	0	0	Ran-off-road	2	Day	Dry	No	5	45	NA

1 mi/h = 1.61 km/h
Note: PDO = Property Damage Only crash
NS = Not Stated
NA = Not Applicable

SITE CHARACTERISTICS

Of the 100 experimental sites on nonlimited access highways that were examined in the study, speed limits were lowered at 59 locations and raised at 41 sites. The number of experimental sites and their section length, stratified by area population and level of speed limit change, is shown in table 3. Changes in the posted speed limit ranged from lowering speed limits by 20 mi/h (32 km/h) on three sections to raising the posted limit by 15 mi/h (24 km/h) at three other locations. Of the 100 sites, 6 roadways were multilane, covering 14 mi (23 m). The remainder of the sections were two-lane highways.

The largest number of experimental sites (63), and nearly 80 percent of the total mileage included in the study, were located in rural areas with a population of less than 5,000 persons. Of the 63 rural sites, 24 sections were located on primary highways that passed through small towns and unincorporated areas. Speed limits were raised at 25 of the 63 rural locations and lowered at 38 sites.

In addition, 22 sites, which were typically less than 1 mi (1.6 km) in length, were located in small urban areas with a population between 5,000 and 50,000 persons. Speed limits were raised at 5 of the 22 small urban sites and lowered at 17 sites.

Finally, 15 sites were located in urban areas with a population of more than 50,000 persons. Speed limits were raised at 11 urban sites and lowered at only 4 locations.

Speed limits were lowered by 10 mi/h (16 km/h) at 35 percent of the sites. The second largest speed limit change occurred at 26 sites, where speed limits were raised by 5 mi/h (8 km/h). The raised 5-mi/h (8-km/h) group also contained approximately 43 percent of the total study mileage. Most of this mileage was at the rural sites where the average section length was 4 mi (6 km).

Sites where speed limits were lowered by either 15 or 20 mi/h (24 or 32 km/h) had the highest before posted speed limits, i.e., 50 or 55 mi/h (81 or 89 km/h). By contrast, sites where speed limits were raised by 10 or 15 mi/h (16 or 24 km/h) had the lowest before posted speed limits, i.e., between 20 and 40 mi/h (32 and 64 km/h).

The 24-h before traffic volumes at the experimental sites ranged from 300 vehicles at a low-volume site to 17,000 vehicles at a high-volume location. The average 24-h before volume for all experimental sites was 4,500 vehicles. At the comparison sites, the 24-h before volumes ranged from a low of 200 vehicles to a high of 22,000 vehicles. The average 24-h before volume for all comparison sites was 3,400 vehicles.

A summary of the characteristics for each experimental and comparison site is given in appendix A. The sites are grouped in appendix A by the amount the posted speed limit was changed at the experimental sites to provide consistency with the analyses presented in subsequent sections of this report.

Table 3. Experimental sites by area type and level of speed limit change.

Area*	Speed Limit Change, mi/h							Total
	Lower Limit				Raise Limit			
	-20	-15	-10	-5	+5	+10	+15	
Rural								
Sites	2	7	22	7	16	7	2	63
Miles	9.45	10.03	29.04	12.52	64.24	9.86	1.12	136.26
Small Urban								
Sites	1	-	11	5	3	2	-	22
Miles	0.80	-	9.19	5.49	2.21	2.03	-	19.72
Urban								
Sites	-	-	2	2	7	3	1	15
Miles	-	-	1.25	1.88	8.15	3.01	1.74	16.03
Total								
Sites	3	7	35	14	26	12	3	100
Miles	10.25	10.03	39.48	19.89	74.60	14.90	2.86	172.01

1 mi/h = 1.61 km/h
1 mi = 1.61 km
*Note: Rural = area population <5,000 persons
Small Urban = area population 5,000 to 49,999 persons
Urban = area population >50,000 persons

In addition to simply noting how much the speed limit was raised or lowered in mi/h (km/h), another way of describing the change in posted speed limit at a site is to compare where the posted speed limit is set relative to the distribution of vehicle speeds before and after the speed limit change. For example, a speed limit set at the 85th percentile speed would have 85 percent of the drivers traveling at or below the speed limit and 15 percent driving above the limit. In this example, the percentile speed posted would be the 85th percentile.

Using the before and after 24-h free-flow speed data collected during the study, the percentile speed posted was determined for each experimental site. Speed data were available for 57 of the 59 sites where speed limits were lowered and for 41 sites where speed limits were raised. Shown in table 4 are the experimental sites grouped by percentile speed posted before and after the speed limits were changed.

Of the 57 sites where speed limits were lowered, 42 locations had speed limits set above the 70th percentile speed before the limits were changed. After the limits were lowered, only three sites had limits posted above the 70th percentile speed. The number of sites posted below the 30th percentile speed increased from 3 before the limits were changed to 24 after the new limits were posted.

Table 4. Distribution of experimental sites by before and after percentile speeds posted.

Before Percentile Speed Posted	After Lowering Speed Limit Percentile Speed Posted						
	<30	30-50	50-70	70-85	85-90	>90	Total
	Number of Sites						
<30	3	-	-	-	-	-	3
30-70	11	1	-	-	-	-	12
>70	10	20	9	3	-	-	42
Total	24	21	9	3	-	-	57
Before Percentile Speed Posted	**After Raising Speed Limit Percentile Speed Posted**						
	<30	30-50	50-70	70-85	85-90	>90	Total
	Number of Sites						
<30	6	7	11	4	3	8	32
30-70			3	4	1	-	8
>70						1	1
Total	6	7	14	8	4	2	41

Note: The percentile speed posted is the point on the speed distribution where the speed limit is posted.

Before the speed limits were lowered, the typical site was posted at the 78th percentile speed. At the lower end, one site was posted at the 20th percentile speed, while at the higher end, one site was posted at the 99th percentile speed. After the speed limits were lowered, the speed limit at a typical site was posted at the 33rd percentile speed. One site was posted at the 1st percentile speed, while at the higher end, one site was posted at the 75th percentile speed.

As illustrated in table 4, before the speed limits were raised, 32 of the 41 sites had speed limits set below the 30th percentile speed. After the speed limits were raised, only six sites had limits below the 30th percentile. In contrast, before the speed limits were raised, only one site had a speed limit above the 70th percentile speed. After the limits were raised, 14 of the 41 sites had limits above the 70th percentile speed.

At sites where speed limits were raised, the before speed limit was typically posted at the 20th percentile speed. One site was posted at the 1st percentile speed. At the other extreme, one site was posted at the 70th percentile speed. After the speed limits were raised, the typical speed limit was posted at the 58th percentile speed. One site was posted at the 10th percentile speed and another site was posted at the 97th percentile speed.

After the speed limit changes were made at the experimental sites, on average, the speed limit was posted at the 43rd percentile speed. By way of comparison, the speed limit posted at the comparison sites, where no speed limit changes were made, was, on average, the 45th percentile speed.

For the sites included in this study, these data suggest that the participating jurisdictions typically post speed limits below the 50th percentile speed. The 85th percentile speed has been cited as one factor considered by all States and most localities in making speed limit changes.[3] Based on the data collected at the study sites, it appears that other factors are more important than the 85th percentile speed in the decision-making process.

Shown in figure 6 is the range in 85th percentile speeds by posted speed limit after the limits were changed on the experimental sections. On average, the speed limits were posted 5 to 16 mi/h (8 to 26 km/h) below the 85th percentile speed. The largest difference occurred at a site with a 47-mi/h (76-km/h) 85th percentile speed and a posted limit of 25 mi/h (40 km/h). At the other extreme, one site had an 85th percentile speed of 41 mi/h (66 km/h) and a posted limit of 45 mi/h (72 km/h).

The range in mean speeds by posted limit, after the limits were changed on the experimental sites, is presented in figure 7. The data illustrate that the posted limits were set slightly below the average speed of traffic for the majority of sites.

The range in 85th percentile speeds by posted speed limit for the comparison sites is shown in figure 8. The data indicate that the existing speed limits on these sections were posted 4 to 12 mi/h (6 to 19 km/h) below the 85th percentile speed. The range in mean speed by posted limit for the comparison sites is illustrated in figure 9.

The findings on the comparison sites are similar to those at the experimental sites, i.e., on average, the speed limits on the comparison sites were posted below the 50th percentile speed or average speed of traffic.

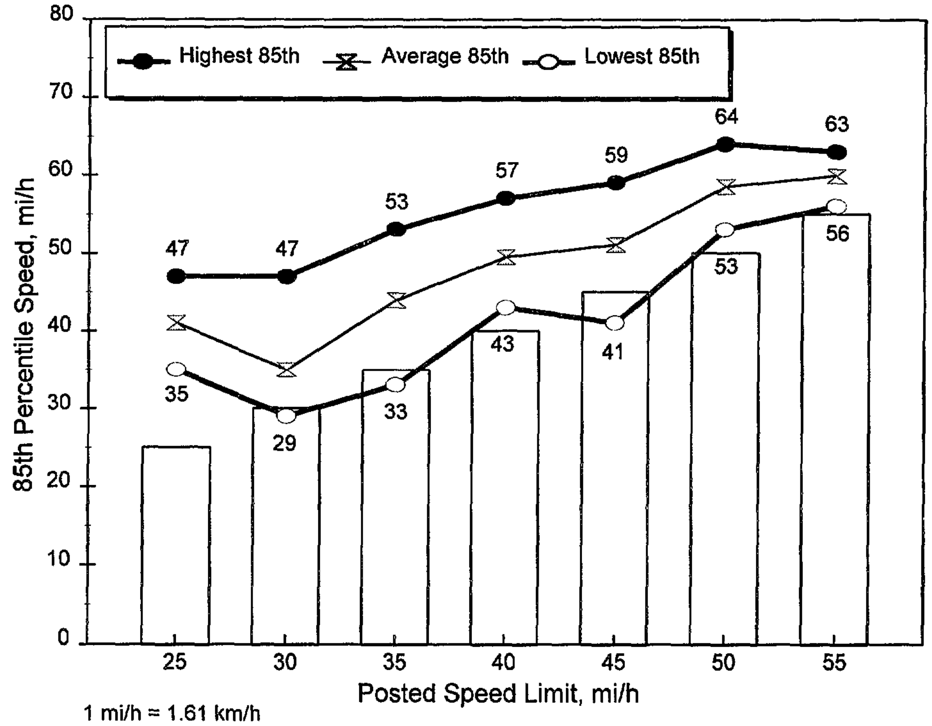


Figure 6. 85th percentile speed vs. posted speed limit for the experimental sites after the speed limits were altered.

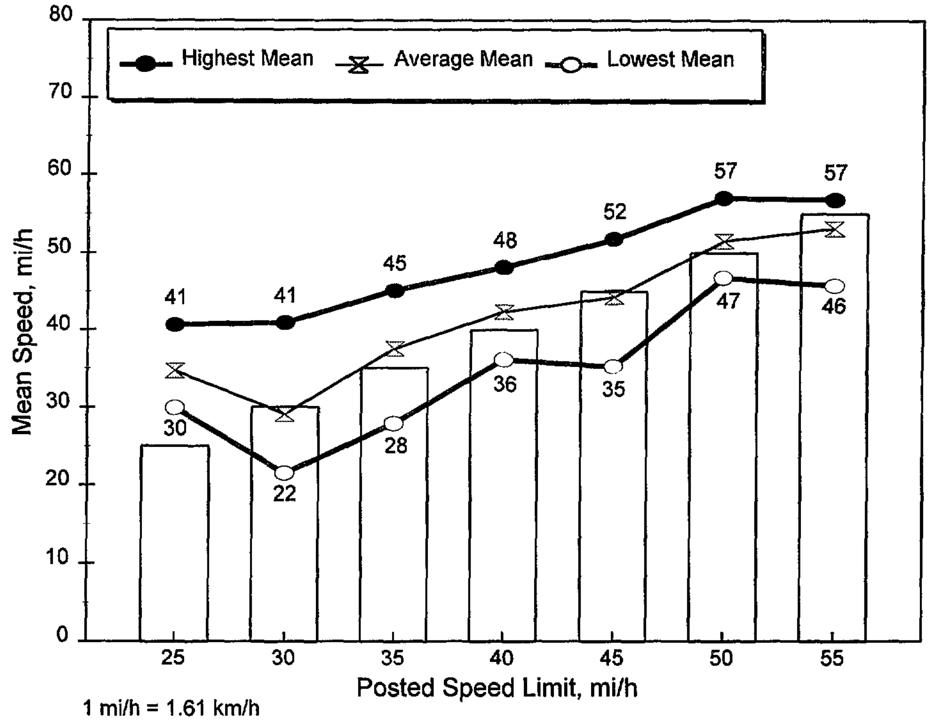


Figure 7. Mean speed vs. posted speed limit for the experimental sites after the speed limits were altered.

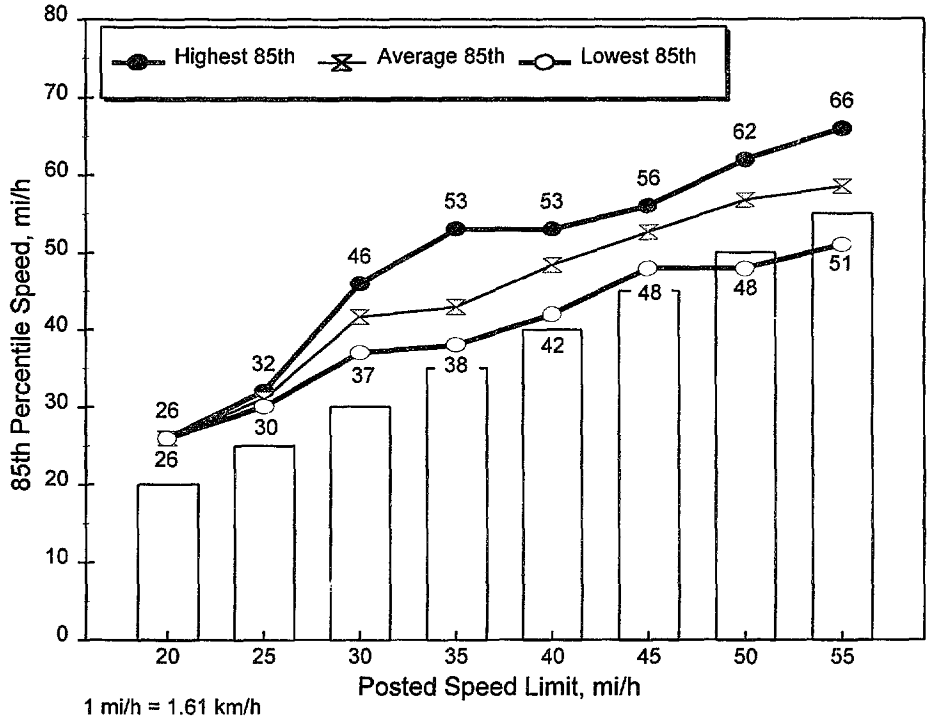


Figure 8. 85th percentile speed vs. posted speed limit for the comparison sites.

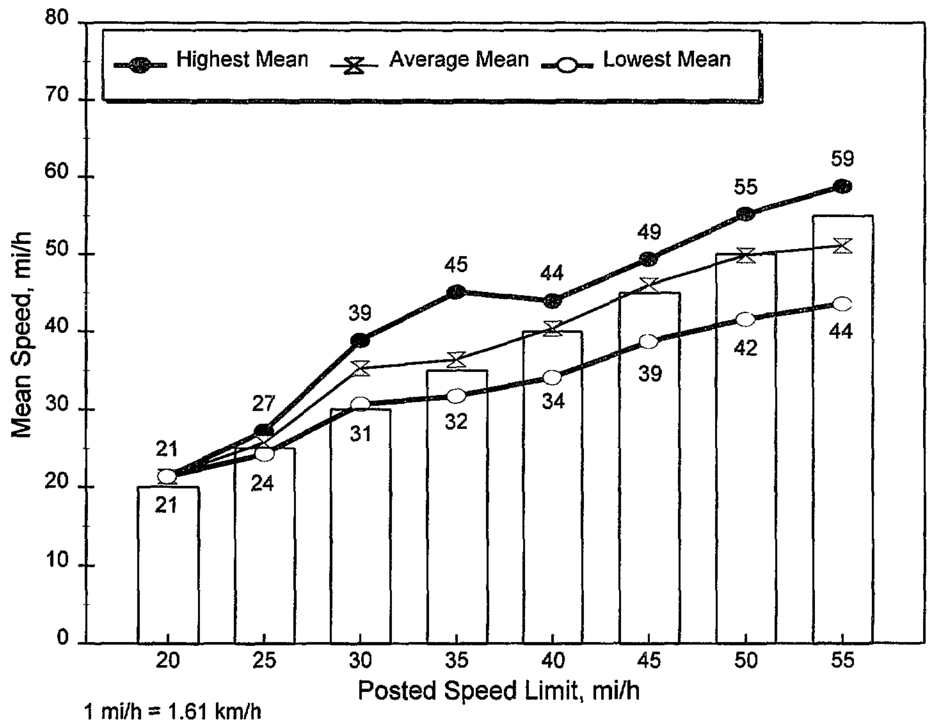


Figure 9. Mean speed vs. posted speed limit for the comparison sites.

EFFECTS ON DRIVER BEHAVIOR

The effects of raising and lowering posted speed limits on driver behavior at the nonlimited access roadway sites selected for study are presented in this section. The specific effects of speed limit changes on driver behavior include changes in the speed distribution, driver compliance, and close following.

Also presented in this section are the results of repeated speed measurements taken at 11 sites to examine speed changes over time, and the results of before and after speed data collected to examine the indirect effects of speed limit changes at 5 contiguous sites. The section concludes with a general discussion of the findings.

Effects on Speed

The before and after results for the 98 experimental sites where speed data were collected are presented in this section, followed by a discussion of speed changes at 4 sites where the pavement was also resurfaced after speed limits were raised. Finally, before and after speed changes at sites where the speed limits were lowered more than 5 mi/h (8 km/h) below the 85th percentile speed are given along with the results of speed changes at sites where the speed limits were raised to within 5 mi/h (8 km/h) of the 85th percentile speed.

The primary objective of the data analysis was to examine before and after differences in driver behavior. The first step in the analysis was to examine before and after differences in driver behavior at each site. The next step was to decide how to group or categorize the sites to simplify presentation of the results. Because raising posted speed limits could produce speed effects that were different than lowering speed limits, the sites were subdivided into raised posted speed limit (41 sites) and lowered posted speed limit (57 sites) groups. In addition to this basic subdivision, the sites were grouped into a number of categories, including amount of posted speed limit change, area population, geographic area (Western States, Southeastern States, etc.), number of lanes, traffic volume level, section length, and operating speed. Irrespective of how the sites were grouped, the results were similar. For presentation purposes in this report, the sites were grouped by amount of posted speed limit change.

Although the sites were grouped by level of posted speed limit change, considerable individual site data are presented in this section and more detailed information is included in appendix B.

Posted speed limit changes at the 98 experimental sites with before and after speed data ranged from lowering the limit by 20 mi/h (32 km/h) at 2 sites, to raising the limit by 15 mi/h (24 km/h) at 3 other sites. However, as the posted limit was lowered by 20 mi/h (32 km/h) at only two sites, these locations were grouped with the 15-mi/h (24-km/h) lower limit sites for analysis. Similarly, as the speed limit was raised by 15 mi/h (24 km/h) at only three sites, these sites were grouped with the 10-mi/h (16-km/h) raised limit sites for analysis.

The posted speed limit groups and the number of experimental sites in each group are shown below.

Category	Posted Speed Limit Group	Number of Experimental Sites
Lower Limit	-15 & -20 mi/h	9
	-10 mi/h	34
	-5 mi/h	14
Raise Limit	+5 mi/h	26
	+10 & +15 mi/h	15

1 mi/h = 1.61 km/h

Speed Variables

As discussed earlier, 24-h speed data were collected for free-flow vehicles (vehicles with a headway of 4 s or more) simultaneously at the experimental and comparison sites before and after the new speed limits were posted. In addition to total volume and free-flow volume, the following spot speed statistics were summarized for analysis:

- Mean speed.
- Standard deviation of speeds.
- Percentile speeds, ranging from the 1st to the 99th percentile.
- Percentage of vehicles exceeding the speed limit by 0, 5, 10, 15, and 20 mi/h (0, 8, 16, 24, and 32 km/h).
- Lower and upper limits of the 10-mi/h (16-km/h) pace and percentage of vehicles in the pace.
- Skewness index.

The skewness index, a measure of the departure of the speed distribution from symmetry, is defined as:

$$SI = \frac{2(P_{93} - P_{50})}{P_{93} - P_{7}}$$

where: SI = Skewness index
P_7 = 7th percentile speed
P_{50} = 50th percentile speed
P_{93} = 93rd percentile speed

Results

A summary of the effects of changing posted speed limits on vehicle speeds is presented in this section. Detailed before and after speed data for each experimental and comparison site are shown in appendix B. Also included in appendix B are tables showing the differences in the before and after speed characteristics at each site.

Previous studies of posted speed limit alterations primarily focused on changes in the mean and 85th percentile speeds. Shown in figure 10 are the before and after 85th percentile speeds for the 57 experimental sites where speed limits were lowered. The before and after 85th percentile speeds for the 41 sites where speed limits were raised are shown in figure 11

If lowering the posted speed limit reduces the 85th percentile speed, then the symbols shown in figure 10 would fall below the diagonal line. Conversely, if raising speed limits increases the 85th percentile speed, then the symbols shown in figure 11 should fall above the diagonal line. However, as shown in figures 10 and II, the symbols appear to be uniformly distributed around the diagonals, irrespective of how much the speed limit was lowered or raised.

Lowering or raising the posted speed limits at the experimental sites had little effect on driver behavior as reflected by the 85th percentile speeds. Lowering the speed limit by 5, 10, 15, or 20 mi/h (8, 16, 24, or 32 km/h) at the study sites did not result in major reductions such as 5 mi/h (8 km/h) or more in the 85th percentile speeds. Raising the speed limit by 5, 10, or 15 mi/h (8, 16, or 24 km/h) at the study sites also did not result in major increases such as 5 mi/h (8 km/h) or more in the 85th percentile speeds.

Figures 10 and 11 provide a graphical illustration of the before and after 85th percentile speeds for each site. The sites were grouped by level of posted speed limit change, and the before and after differences in 85th percentile speeds are shown in figure 12. The average change in 85th percentile speed for the sites in each speed limit group, as well as the largest change at any individual experimental site in the group, is shown in figure 12. For example, for the group of sites where speed limits were lowered by 15 or 20 mi/h (24 or 32 km/h), the average change in 85th percentile speed was a 0.1-mi/h (0.16-km/h) decrease. Among the nine sites in this group, the largest decrease in 85th percentile speed at an individual site was 1 mi/h (1.6 km/h). The largest increase in 85th percentile speed at an individual site was 2 mi/h (3.2 km/h).

The data in figure 12 illustrate that major reductions, 5 mi/h (8 km/h) or more, in the 85th percentile speeds did not occur even for large reductions in the posted speed limit. Also, major increases in the 85th percentile speeds did not occur at sites where the speed limits were raised. As shown in figure 13, small changes in the 85th percentile speeds also occurred at the comparison sites where speed limits were not altered.

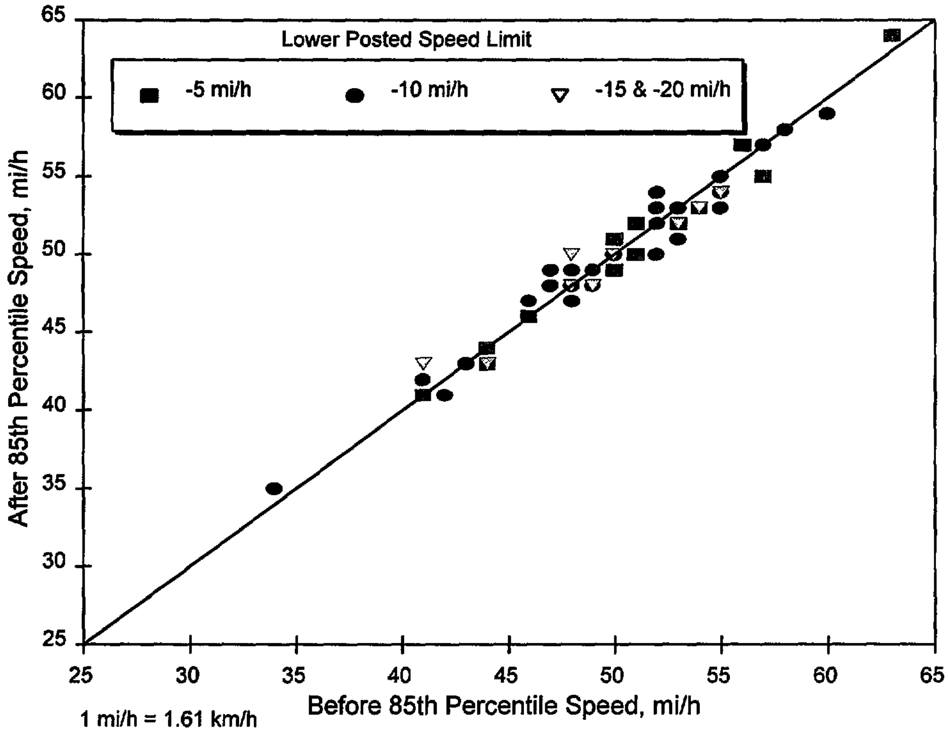


Figure 10. 85th percentile speeds before and after lowering posted speed limits at 57 experimental sites.

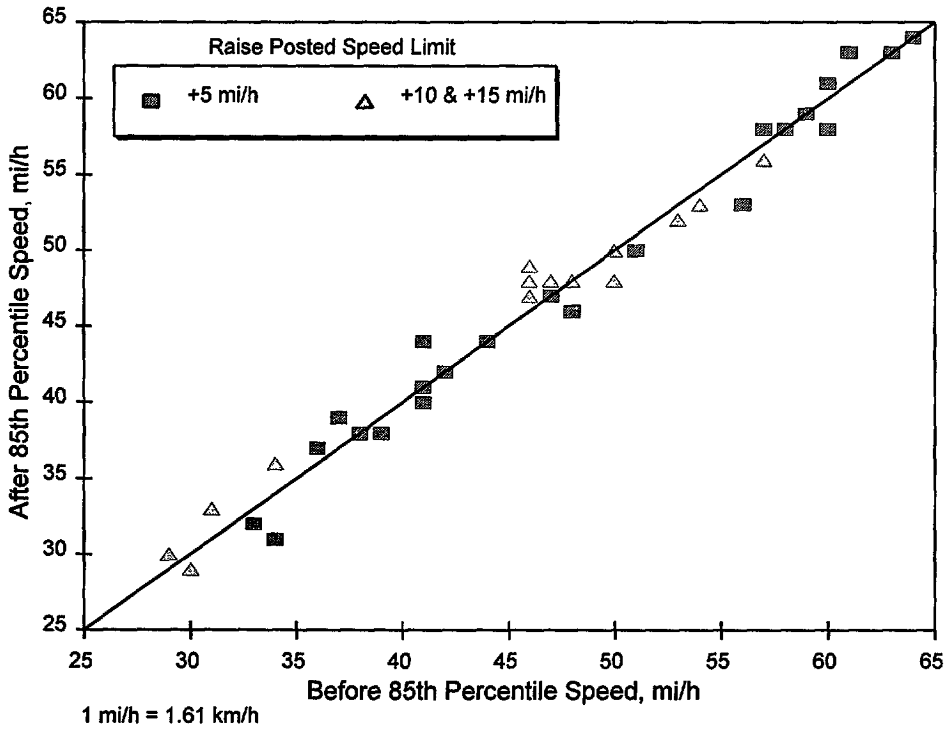


Figure 11. 85th percentile speeds before and after raising posted speed limits at 41 experimental sites.

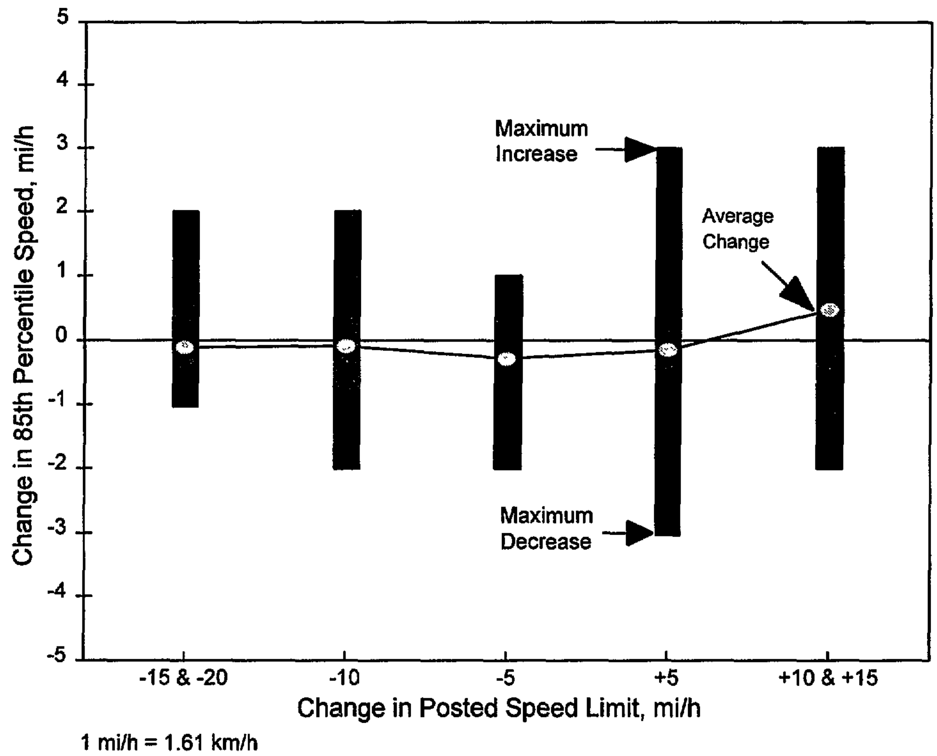


Figure 12. Maximum and average changes in the 85th percentile speeds at the experimental sites.

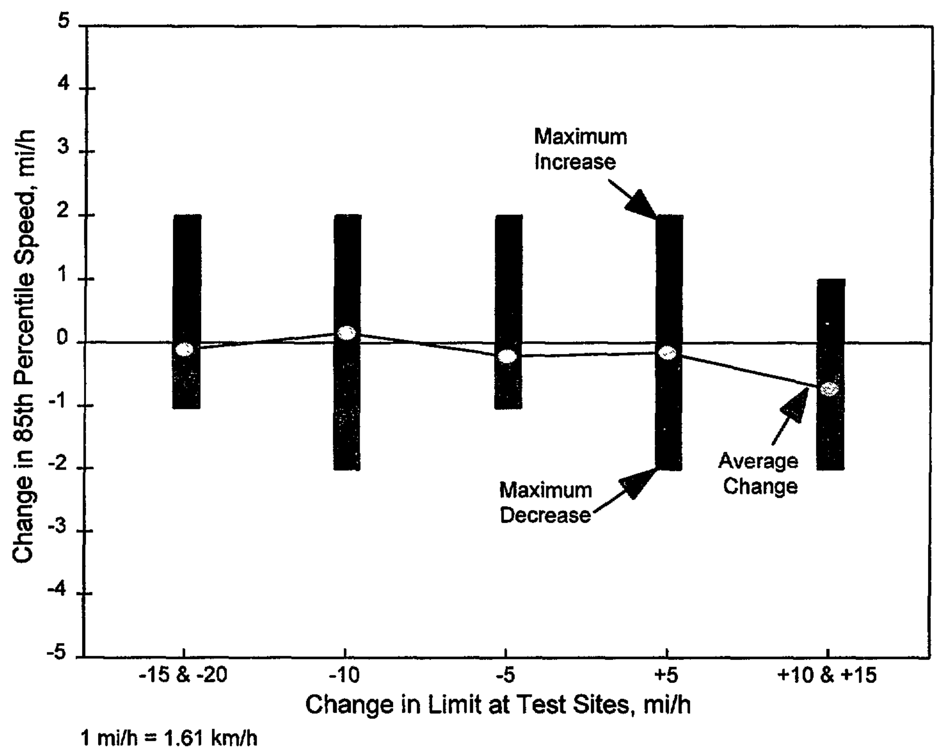


Figure 13. Maximum and average changes in the 85th percentile speeds at the comparison sites.

The 85th percentile speed is only one parameter in the speed distribution. Shown in table 5 are the before and after means, 85th percentile speeds, and the differences in speeds for each of the raised and lowered speed limit groups. The data for each experimental and comparison site are shown in table 6.

Examination of table 5 reveals that there were small differences (less than 1 mi/h (1.6 km/h)) in the group mean and 85th percentile speeds for each posted speed limit group. The standard deviation of the differences, however, is large, indicating considerable site-to-site variation.

A review of the speed data in table 6 at each experimental site revealed that before and after differences in the mean, standard deviation, and 85th percentile speed were generally less than 2 mi/h (3.2 km/h). In addition, there were increases in speeds at some sites and decreases in speeds at other sites, irrespective of whether the speed limit was raised or lowered or the amount the speed limit was changed. As also shown in table 6, similar differences in speed occurred at the comparison sites where posted speed limits were not changed. It should be noted that many of the speed differences of 1 mi/h (1.6 km/h) or more are statistically significant due to the large 24-h speed samples collected.

Table 5. Before and after group mean and 85th percentile speeds.

Speed Limit Group	Group Mean Speed Before	Group Mean Speed After	Group Mean Speed Diff.	Std. Dev. Diff.	Group 85th Percentile Speed Before	Group 85th Percentile Speed After	Group 85th Percentile Speed Diff.	Std. Dev. Diff.
Experimental Sites								
-15 & -20	42.1	42.2	0.1	0.9	49.1	49.0	-0.1	1.3
-10	42.7	42.7	0.1	1.0	50.0	49.9	-0.1	1.0
-5	43.7	43.7	-0.0	0.6	50.7	50.4	-0.3	1.0
+5	41.9	42.2	0.2	1.2	48.5	48.4	-0.2	1.4
+10 & +15	36.7	37.5	0.8	1.5	43.3	43.8	0.5	1.5
Comparison Sites								
-15 & -20	47.7	47.7	0.1	1.1	55.6	55.4	-0.1	1.1
-10	47.8	48.1	0.4	1.0	55.3	55.5	0.2	1.0
-5	46.2	46.4	0.2	1.0	53.1	52.9	-0.2	1.0
+5	40.5	40.4	-0.1	1.1	47.0	46.8	-0.2	1.1
+10 & +15	32.9	32.9	-0.0	1.1	39.5	38.8	-0.7	1.1

1 mi/h = 1.61 km/h
Note: All speed limits and vehicle speeds are shown in mi/h.

Table 6. Before and after vehicle speeds for the experimental and comparison sites.

Experimental Site Number	Before Limit	After Limit	Diff. Limit	Before Mean Speed	After Mean Speed	Diff. Mean Speed	Before Std. Dev. Speed	After Std Dev. Speed	Diff. Std. Dev. Speed	Before 85th Speed	After 85th Speed	Diff. 85th Speed
Speed Limit Lowered by 15 or 20 mi/h at Experimental Sites												
NJ04E	50	30	-20	37.7	37.8	0.1	6.6	5.5	-1.1	44	43	-1
TX03E	55	35	-20	36.2	37.9	1.7	5.0	4.7	-0.3	41	43	2
DE02E	50	35	-15	45.7	44.9	-0.8	6.8	6 6	-0.2	53	52	-1
NM01E	55	40	-15	44.5	45.2	0.7	9.5	9.0	-0.5	55	54	-1
NM03E	55	40	-15	42.0	41.1	-0.9	7.6	7.8	0.2	50	50	0
NM04E	55	40	-15	40.4	41.4	1.0	7.5	7.8	0.3	48	50	2
OH02E	55	40	-15	42.6	42.1	-0.5	6.3	6.1	-0.2	49	48	-1
OH13E	55	40	-15	41.9	41.9	0.0	5.7	5.4	-0.3	48	48	0
TX05E	55	40	-15	47.9	47.5	-0.4	5.5	5.3	-0.2	54	53	-1
Average for 9 sites				42.1	42.2	0.1	6.7	6.5	-0.3	49.1	49.0	-0.1
Speed Limit Lowered by 10 mi/h at Experimental Sites												
CA01E	35	25	-10	34.3	33.8	-0.5	6.9	6.7	-0.2	42	41	-1
DE03E	50	40	-10	45.0	45.1	0.1	6.9	6.8	-0.1	52	52	0
DE04E	50	40	-10	48.7	48.1	-0.6	7.9	7.9	0.0	57	57	0
IL01E	50	40	-10	43.6	42.9	-0.7	5.1	4.7	-0.4	49	48	-1
IN01E	55	45	-10	46.9	46.7	-0.2	5.8	5.6	-0.2	53	53	0
MA01E	40	30	-10	41.9	40.9	-1.0	5.8	5.4	-0.4	48	47	-1
ME02E	45	35	-10	33.0	33.4	0.4	7.2	7.2	0.0	41	42	1
MI09E	55	45	-10	49.7	50.5	0.8	8.8	7.9	-0.9	58	58	0
NE01E	55	45	-10	44.2	42.5	-1.7	7.5	6.7	-0.8	52	50	-2
NJ02E	45	35	-10	37.7	37.7	0.0	8.0	7.0	-1.0	46	46	0
NJ03E	45	35	-10	41.0	41.5	0.5	6.8	6.3	-0.5	48	48	0
OH01E	55	45	-10	53.0	51.7	-1.3	7.0	7.4	0.4	60	59	-1
OH03E	55	45	-10	48.2	48.6	0.4	6.3	6.2	-0.1	55	55	0
OH04E	55	45	-10	45.8	45.1	-0.7	7.6	7.3	-0.3	54	53	-1
OH05E	45	35	-10	38.7	38.8	0.1	7.6	6.6	-1.0	46	46	0
OH06E	55	45	-10	44.1	44.6	0.5	9.0	8.1	-0.9	53	53	0
OH07E	55	45	-10	43.3	44.4	1.1	6.4	5.8	-0.6	50	50	0
OH08E	55	45	-10	39.1	39.8	0.7	7.5	8.1	0.6	47	49	2
OH09E	55	45	-10	42.7	42.7	0.0	6.8	6.7	-0.1	49	49	0
OH10E	55	45	-10	46.7	44.7	-2.0	6.3	5.8	-0.5	53	51	-2

Comparison Site Number	Posted Limit	Before Mean Speed	After Mean Speed	Diff. Mean Speed	Before Std. Dev. Speed	After Std. Dev. Speed	Diff. Std. Dev. Speed	Before 85th Speed	After 85th Speed	Diff. 85th Speed
Comparison Sites where Posted Speed Limits were not changed										
NJ04C	50	47.6	46.6	-1.0	5.5	6.0	0.5	54	53	-1
TX03C	55	49.6	52.3	2.7	10.4	7.8	-2.6	59	60	1
DE02C	50	44.5	44.9	0.4	6.9	7.5	0.6	51	53	2
NM01C	55	52.2	52.2	0.0	7.7	7.9	0.2	60	60	0
NM03C	40	44.2	43.6	-0.6	9.8	8.5	-1.3	54	53	-1
NM04C	40	44.2	43.6	-0.6	9.8	8.5	-1.3	54	53	-1
OH02C	55	46.6	45.9	-0.7	7.2	7.0	-0.2	55	54	-1
OH13C	55	47.5	47.6	0.1	6.2	6.7	0.5	54	54	0
TX05C	55	52.6	53.0	0.4	6.4	6.0	-0.4	59	59	0
Average for 9 sites		47.7	47.7	0.1	7.8	7.3	-0.4	55.6	55.4	-0.1
Comparison Sites where Posted Speed Limits were not changed										
CA01C	30	34.0	33.5	-0.5	5.6	5.4	-0.2	40	39	-1
DE03C	50	49.5	49.6	0.1	8.6	8.7	0.1	58	58	0
DE04C	50	49.3	49.5	0.2	8.7	8.8	0.1	58	58	0
IL01C	45	43.6	43.3	-0.3	5.6	4.9	-0.7	49	48	-1
IN01C	55	52.9	53.4	0.5	6.6	6.7	0.1	60	60	0
MA01C	30	37.9	38.0	0.1	6.3	5.7	-0.6	45	44	-1
ME02C	45	46.5	47.7	1.2	7.5	6.9	-0.6	54	55	1
MI09C	55	56.7	57.0	0.3	7.2	6.8	-0.4	64	64	0
NE01C	55	52.1	52.6	0.5	8.3	7.8	-0.5	59	60	1
NJ02C	50	50.6	50.5	-0.1	7.9	7.0	-0.9	59	57	-2
NJ03C	50	50.2	50.5	0.3	7.7	7.0	-0.7	58	58	0
OH01C	55	51.6	50.9	-0.7	9.4	9.5	0.1	61	60	-1
OH03C	55	52.9	52.9	0.0	7.7	7.6	-0.1	61	61	0
OH04C	55	46.8	47.5	0.7	5.9	5.9	0.0	53	54	1
OH05C	55	50.0	50.2	0.2	11.1	10.5	-0.6	59	60	1
OH06C	55	52.7	53.2	0.5	7.4	7.9	0.5	61	61	0
OH07C	55	43.8	43.6	-0.2	8.4	7.2	-1.2	52	51	-1
OH08C	55	56.4	56.8	0.4	8.5	9.0	0.5	65	66	1
OH09C	55	54.4	54.7	0.3	6.4	6.0	-0.4	61	61	0
OH10C	55	54.4	54.7	0.3	6.4	6.0	-0.4	61	61	0

1 mi/h = 1.61 km/h

Note: All speed limits and vehicle speeds are shown in mi/h.

Table 6. Before and after vehicle speeds for the experimental and comparison sites (continued).

Experimental Site Number	Before Limit	After Limit	Diff. Limit	Before Mean Speed	After Mean Speed	Diff. Mean Speed	Before Std. Dev. Speed	After Std. Dev. Speed	Diff. Std. Dev. Speed	Before 85th Speed	After 85th Speed	Diff. 85th Speed	Comparison Site Number	Posted Limit	Before Mean Speed	After Mean Speed	Diff. Mean Speed	Before Std. Dev. Speed	After Std. Dev. Speed	Diff. Std. Dev. Speed	Before 85th Speed	After 85th Speed	Diff. 85th Speed
Speed Limit Lowered by 10 mi/h at Experimental Sites (continued)													**Comparison Sites where Posted Speed Limits were not changed**										
OH11E	50	40	-10	35.5	37.4	1.9	12.6	10.5	-2.1	48	48	0	OH11C	50	41.6	41.6	0.0	6.4	6.2	-0.2	48	48	0
OH12E	55	45	-10	45.6	44.3	-1.3	7.3	7.4	0.1	53	52	-1	OH12C	55	53.3	52.3	-1.0	7.4	6.8	-0.6	61	59	-2
OK01E	45	35	-10	36.4	36.0	-0.4	6.3	6.5	0.2	43	43	0	OK01C	45	46.6	47.6	1.0	7.0	6.4	-0.6	54	54	0
OK02E	35	25	-10	29.5	29.9	0.4	4.8	4.5	-0.3	34	35	1	Comparison site was not available.										
OK03E	35	25	-10	39.3	40.6	1.3	6.0	5.9	-0.1	46	47	1	Comparison site was not available.										
OK04E	45	35	-10	42.7	42.3	-0.4	5.7	6.4	0.7	49	49	0	OK04C	35	32.0	31.7	-0.3	5.5	5.6	0.1	38	38	0
TX02E	55	45	-10	48.4	47.5	-0.9	6.5	5.9	-0.6	55	54	-1	TX02C	55	49.6	52.3	2.7	10.4	7.8	-2.6	59	60	1
TX04E	55	45	-10	40.4	41.7	1.3	7.2	7.0	-0.2	48	49	1	TX04C	55	50.5	51.3	0.8	8.6	7.3	-1.3	59	59	0
VA01E	55	45	-10	47.4	46.5	-0.9	7.2	6.6	-0.6	55	53	-2	VA01C	55	44.7	46.0	1.3	6.1	5.9	-0.2	51	52	1
VA03E	55	45	-10	44.0	44.8	0.8	6.4	6.2	-0.2	51	52	1	VA03C	55	45.2	45.8	0.6	6.7	8.4	1.7	53	54	1
VA04E	55	45	-10	40.2	40.7	0.5	6.9	6.9	0.0	47	48	1	VA04C	55	45 2	45.8	0.6	6.7	8.4	1.7	53	54	1
VA05E	55	45	-10	44.8	45.0	0.2	8.5	7.7	-0.8	54	53	-1	VA05C	55	45.2	46.8	1.6	6.7	8.1	1.4	53	55	2
VA07E	55	45	-10	44.4	46.8	2.4	7.0	6.4	-0.6	52	54	2	VA07C	55	49.4	50.2	0.8	8.1	8.3	0.2	57	59	2
WV03E	45	35	-10	44.0	45.1	1.1	7.1	7.0	-0.1	52	53	1	WV03C	45	39.0	38.7	-0.3	7.8	8.9	1.1	47	48	1
Average for 34 sites				42.7	42.7	0.1	7.1	6.7	-0.3	50.0	49.9	-0.1	Average for 32 sites		47.8	48.1	0.4	7.5	7.3	-0.2	55.3	55.5	0.2
Speed Limit Lowered by 5 mi/h at Experimental Sites													**Comparison Sites where Posted Speed Limits were not changed**										
AZ01E	50	45	-5	44.8	44.2	-0.6	5.5	5.2	-0.3	51	50	-1	AZ01C	45	46.9	46.7	-0.2	6.5	6.3	-0.2	54	53	-1
CT02E	45	40	-5	39.9	39.9	0.0	5.7	5.6	-0.1	46	46	0	CT02C	45	40.7	40.3	-0.4	8.8	9.0	0.2	49	49	0
CT05E	45	40	-5	44.4	45.4	1.0	5.4	5.3	-0.1	50	51	1	CT05C	45	48.3	49.4	1.1	5.6	5.6	0.0	54	55	1
DE01E	40	35	-5	45.3	45.1	-0.2	8.4	7.1	-1.3	54	53	-1	DE01C	40	33.2	34.1	0.9	6.2	7.4	1.2	40	42	2
ID01E	55	50	-5	49.6	48.6	-1.0	6.9	6.0	-0.9	57	55	-2	ID01C	55	51.5	51.6	0.1	6.6	5.7	-0.9	58	57	-1
ID02E	55	50	-5	50.3	50.7	0.4	5.8	5.5	-0.3	56	57	1	ID02C	55	51.5	51.6	0.1	6.6	5.7	-0.9	58	57	-1
IL02E	50	45	-5	44.8	44.0	-0.8	5.2	5.2	0.0	50	49	-1	IL02C	45	43.6	43.3	-0.3	5.6	4.9	-0.7	49	48	-1
IN05E	45	40	-5	41.7	41.1	-0.6	7.1	6.7	-0.4	50	49	-1	IN05C	45	48.0	48.1	0.1	6.6	6.1	-0.5	55	54	-1
IN06E	50	45	-5	45.4	45.0	-0.4	7.2	6.6	-0.6	53	52	-1	IN06C	50	51.0	51.2	0.2	6.6	6.5	-0.1	58	58	0
IN07E	50	45	-5	44.1	44.7	0.6	7.4	7.3	-0.1	51	52	1	IN07C	50	51.0	51.2	0.2	6.6	6.5	-0.1	58	58	0
MA03E	30	25	-5	33.9	34.2	0.3	6.1	6.4	0.3	41	41	0	MA03C	30	37.6	37.6	0.0	6.8	6.5	-0.3	45	44	-1
ME01E	45	40	-5	36.1	36.1	0.0	7.0	7.2	0.2	44	43	-1	ME01C	45	46.5	47.7	1.2	7.5	6.9	-0.6	54	55	1
NJ01E	40	35	-5	38.3	38.7	0.4	5.7	5.7	0.0	44	44	0	NJ01C	40	44.4	44.0	-0.4	6.3	6.0	-0.3	51	50	-1
NM02E	55	50	-5	53.8	54.6	0.8	8.8	8.8	0.0	63	64	1	NM02C	55	52.2	52.2	0.0	7.7	7.9	0.2	60	60	0
Average for 14 sites				43.7	43.7	-0.0	6.6	6.3	-0.3	50.7	50.4	-0.3	Average for 14 sites		46.2	46.4	0.2	6.7	6.5	-0.2	53.1	52.9	-0.2

1 mi/h = 1.61 km/h
Note. All speed limits and vehicle speeds are shown in mi/h.

Table 6. Before and after vehicle speeds for the experimental and comparison sites (continued).

Experimental Site Number	Before Limit	After Limit	Diff. Limit	Before Mean Speed	After Mean Speed	Diff. Mean Speed	Before Std. Dev. Speed	After Std Dev. Speed	Diff. Std. Dev. Speed	Before 85th Speed	After 85th Speed	Diff. 85th Speed	Comparison Site Number	Posted Limit	Before Mean Speed	After Mean Speed	Diff. Mean Speed	Before Std. Dev. Speed	After Std. Dev. Speed	Diff. Std. Dev. Speed	Before 85th Speed	After 85th Speed	Diff. 85th Speed
Speed Limit Raised by 5 mi/h at Experimental Sites													**Comparison Sites where Posted Speed Limits were not changed**										
AZ02E	25	30	5	31.8	31.9	0.1	5.6	5.4	-0.2	38	38	0	AZ02C	30	31.0	30.6	-0.4	5.7	5.6	-0.1	38	37	-1
AZ03E	30	35	5	32.6	33.6	1.0	5.4	4.5	-0.9	39	38	-1	AZ03C	30	32.1	32.6	0.5	6.9	7.1	0.2	39	40	1
CA06E	45	50	5	48.9	46.8	-2.1	6.4	6.2	-0.2	56	53	-3	CA06C	45	49.9	48.4	-1.5	6.9	6.8	-0.1	57	55	-2
CA07E	45	50	5	53.1	51.3	-1.8	5.9	6.2	0.3	60	58	-2	CA07C	45	49.9	48.0	-1.9	6.9	6.6	-0.3	57	55	-2
CO01E	30	35	5	38.9	38.8	-0.1	4.8	4.5	-0.3	44	44	0	CO01C	30	32.0	32.0	0.0	4.7	4.8	0.1	37	37	0
CO03E	40	45	5	43.3	42.8	-0.5	7.1	6.8	-0.3	51	50	-1	CO03C	30	37.4	36.6	-0.8	5.6	5.4	-0.2	43	42	-1
CT01E	45	50	5	56.4	57.0	0.6	7.0	6.9	-0.1	64	64	0	CT01C	45	49.2	49.3	0.1	6.6	6.8	0.2	56	56	0
CT04E	30	35	5	43.2	43.0	-0.2	7.2	7.1	-0.1	51	50	-1	Comparison site was not available.										
DE05E	35	40	5	37.6	37.6	0.0	8.2	7.7	-0.5	48	46	-2	DE05C	35	34.0	33.5	-0.5	7.7	7.4	-0.3	42	42	0
IN02E	25	30	5	27.6	24.8	-2.8	5.9	5.7	-0.2	34	31	-3	IN02C	25	25.2	24.2	-1.0	5.7	5.8	0.1	31	30	-1
IN03E	25	30	5	26.9	26.5	-0.4	5.6	5.6	0.0	33	32	-1	IN03C	25	25.2	24.2	-1.0	5.7	5.8	0.1	31	30	-1
MD01E	50	55	5	54.8	56.4	1.6	6.3	6.1	-0.2	61	63	2	MD01C	50	54.5	55.0	0.5	6.6	6.5	-0.1	61	62	1
MD02E	50	55	5	51.2	52.1	0.9	5.4	5.3	-0.1	57	58	1	MD02C	50	52.5	52.0	-0.5	6.5	6.7	0.2	59	58	-1
MD03E	50	55	5	51.2	51.1	-0.1	6.9	7.2	0.3	58	58	0	MD03C	50	53.0	53.9	0.9	5.7	5.6	-0.1	58	60	2
MD04E	50	55	5	53.3	53.6	0.3	6.3	6.8	0.5	60	61	1	MD04C	50	44.7	46.1	1.4	6.9	7.0	0.1	52	54	2
MD05E	50	55	5	53.8	54.9	1.1	6.1	6.7	0.6	60	61	1	MD05C	50	53.8	55.2	1.4	5.9	5.4	-0.5	60	61	1
MD06E	30	35	5	40.6	40.8	0.2	6.0	6.0	0.0	47	47	0	MD06C	30	34.9	34.6	-0.3	7.2	6.9	-0.3	42	42	0
MD07E	30	35	5	35.7	36.0	0.3	6.0	5.7	-0.3	42	42	0	MD07C	30	34.9	34.6	-0.3	7.2	6.9	-0.3	42	42	0
MD08E	30	35	5	30.7	33.1	2.4	5.9	6.3	0.4	37	39	2	MD08C	30	34.9	34.6	-0.3	7.2	6.9	-0.3	42	42	0
MD09E	30	35	5	35.2	35.9	0.7	5.0	4.6	-0.4	41	41	0	MD09C	30	37.2	37.7	0.5	6.0	5.5	-0.5	44	4.4	0
MD10E	50	55	5	53.7	54.2	0.5	5.0	5.0	0.0	59	59	0	MD10C	50	50 1	50.3	0.2	5.2	5.1	-0.1	55	55	0
MS02E	30	35	5	34.0	35.9	1.9	6.9	7.6	0.7	41	44	3	MS02C	30	34.4	34.5	0.1	5.2	4.9	-0.3	40	40	0
TN01E	50	55	5	56.8	56.8	0.0	6.2	6.1	-0.1	63	63	0	TN01C	55	59.2	58.8	-0.4	6.1	6.1	0.0	66	65	-1
TX06E	30	35	5	33.0	33.3	0.3	7.1	6.6	-0.5	41	40	-1	TX06C	30	36.5	37.9	1.4	7.2	6.9	-0.3	44	45	1
TX07E	40	45	5	35.1	35.2	0.1	5.9	6.0	0.1	41	41	0	TX07C	35	33.0	32.4	-0.6	5.3	5.0	-0.3	39	38	-1
TX08E	30	35	5	30.6	32.5	1.9	4.8	4.7	-0.1	36	37	1	TX08C	35	33.0	32.4	-0.6	5.3	5.0	-0.3	39	38	-1
Average for 26 sites				41.9	42.2	0.2	6.1	6.1	-0.1	48.5	48.4	-0.2	Average for 25 sites		42.3	42.5	0.2	6.2	6.0	-0.2	48.7	48.9	0.1

1 mi/h = 1.61 km/h

Note: All speed limits and vehicle speeds are shown in mi/h.

Table 6. Before and after vehicle speeds for the experimental and comparison sites (continued).

Experimental Site Number	Before Limit	After Limit	Diff. Limit	Before Mean Speed	After Mean Speed	Diff. Mean Speed	Before Std. Dev. Speed	After Std. Dev. Speed	Diff. Std. Dev. Speed	Before 85th Speed	After 85th Speed	Diff. 85th Speed
Speed Limit Raised by 10 or 15 mi/h at Experimental Sites												
CO02E	30	40	**10**	**40.9**	42.3	1.4	5.6	5.4	-0.2	47	48	1
CT03E	30	40	**10**	44.9	45.4	0.5	7.1	6.7	-0.4	53	52	
ID03E	20	30	**10**	24.2	25.0	0.8	4.8	4.4	-0.4	29	30	1
ID04E	20	30	**10**	23.1	24.1	1.0	6.0	5.6	-0.4	29	30	1
ID05E	20	30	**10**	21.7	21.5	-0.2	7.6	6.6	-1.0	30	29	-1
ID06E	25	35	**10**	29.0	30.6	1.6	4.9	5.5	0.6	34	36	2
ID07E	25	35	**10**	27.1	27.9	0.8	4.0	4.6	0.6	31	33	2
ID08E	35	45	**10**	39.2	41.0	1.8	5.8	5.3	-0.5	46	47	1
MA02E	30	40	**10**	41.9	41.9	0.0	6.1	5.8	-0.3	40	48	0
ME03E	35	45	**10**	46.7	46.1	-0.6	7.0	6.7	-0.3	54	53	-1
MS01E	35	45	**10**	38.9	42.8	3.9	6.8	6.5	-0.3	46	49	3
VA02E	35	45	**10**	39.9	43.0	3.1	5.2	5.2	0.0	46	48	2
CA04E	30	45	15	43.6	42.2	-1.4	5.7	5.3	-0.4	50	48	-2
IN04E	30	45	15	41.8	43.1	1.3	7.3	6.6	-0.7	50	50	0
TX01E	40	55	15	47.3	45.8	-1.5	10.0	9.1	-0.9	57	52	-1
Average for 15 sites				**36.7**	**37.5**	**0.8**	**6.3**	**6.0**	**-0.3**	**43.3**	**43.8**	**0.5**

Comparison Site Number	Posted Limit	Before Mean Speed	After Mean Speed	Diff. Mean Speed	Before Std. Dev. Speed	After Std. Dev. Speed	Diff. Std. Dev. Speed	Before 85th Speed	After 85th Speed	Diff. 85th Speed
Comparison Sites where Posted Speed Limits were not changed										
CO02C	30	32.0	32.0	0.0	4.7	4.8	0.1	37	37	0
Comparison site was not available.										
ID03C	20	21.3	21.3	0.0	5.3	4.8	-0.5	28	26	-2
ID04C	20	21.3	21.3	0.0	5.3	4.8	-0.5	28	26	-2
ID05C	20	21.3	21.3	0.0	5.3	4.8	-0.5	28	26	-2
ID06C	25	27.3	27.2	-0.1	4.2	4.3	0.1	32	32	0
ID07C	25	28.0	27.2	-0.8	4.2	4.3	0.1	32	32	0
ID08C	35	32.8	32.6	-0.2	6.2	5.8	-0.4	40	38	-2
MA02C	30	37.9	38.0	0.1	6.3	5.7	-0.6	45	44	-1
ME03C	35	42.2	42.8	0.6	7.5	7.6	0.1	50	50	0
MS01C	35	43.7	45.1	1.4	7.8	7.6	-0.2	52	53	1
VAO2C	35	40.3	40.6	0.3	5.3	5.3	0.0	46	46	0
CA04C	30	40.1	38.8	-1.3	6.7	7.1	0.4	47	46	-1
IN04C	30	34.7	35.8	1.1	7.6	7.4	-0.2	42	43	1
TX01C	40	38.0	36.8	-1.2	7.6	7.3	-0.3	46	44	-2
Average for 15 sites		32.9	32.9	-0.0	6.0	5.8	-0.2	39.5	38.8	-0.7

1 mi/h = 1.61 km/h
Note: All speed limits and vehicle speeds are shown in mi/h.

Unlike many previous studies which only reported changes in the mean and 85th percentile speeds, the 24-h data collected during this effort permitted examination of the entire speed distribution. Shown in figure 14 is the before and after cumulative frequency distributions of free-flow vehicle speeds for a site in Ohio (OH01 E) where the speed limit was lowered from 55 to 45 mi/h (89 to 72 km/h) in a rural community. The two-lane site is 0.52 mi (0.84 km) long and the before 24-h volume was 3,900 vehicles. As indicated in the figure, before and after speed differences along the entire distribution are 2 mi/h (3 km/h) or less, which is typical of the findings at most of the experimental and comparison sites.

Another example of the before and after speed distributions is given in figure 15 for a main two-lane street in an Idaho city (ID03E) where the population was less than 5,000 persons. The speed limit on the 1.79-mi (2.88-km) section was raised from 20 to 30 mi/h (32 to 48 km/h). The before 24-h volume was 1,400 vehicles. As shown in figure 15, the before and after speed differences are 2 mi/h (3 km/h) or less.

The changes in the speed distributions illustrated in figures 14 and 15 are but 2 examples from the 98 experimental sites. As shown in more detail in appendix B, there were site-to-site variations in the before and after percentile speeds for both the experimental and comparison locations.

To provide a summary of the before and after speed differences, the sites were grouped by amount of posted speed limit change. Mean changes in the speed distribution were calculated for each posted speed limit group. The mean changes for the speed limit groups are summarized in appendix B. Because 24-h free-flow speed data were collected before and after speed limits were changed, the samples are large. For example, the speed limit group with the smallest sample is nine sites where speed limits were lowered by 15 or 20 mi/h (24 or 32 km/h). For this group, the before period 50th percentile contains the speeds of more than 8,900 free-flow vehicles. The 1st and 99th percentiles each contain approximately 180 vehicle speeds. The speed limit group with the largest number of sites (lowered by 10 mi/h (16 km/h)) contains more than 61,000 free-flow vehicle speeds in the 50th percentile, and more than 1,200 vehicle speeds each in the 1st and 99th percentiles.

Mean differences in the before and after percentile speeds for the group of sites where speed limits were lowered and raised, by amount of posted speed limit change, are shown in figures 16 and 17, respectively. Mean changes in the before and after percentile speeds for the comparison site groups, where speed limits were not changed, are shown in figures 18 and 19, respectively. Finally, the net effects of the changes, obtained by subtracting the differences at the comparison sites from the differences at the experimental sites, are shown in figures 20 and 21.

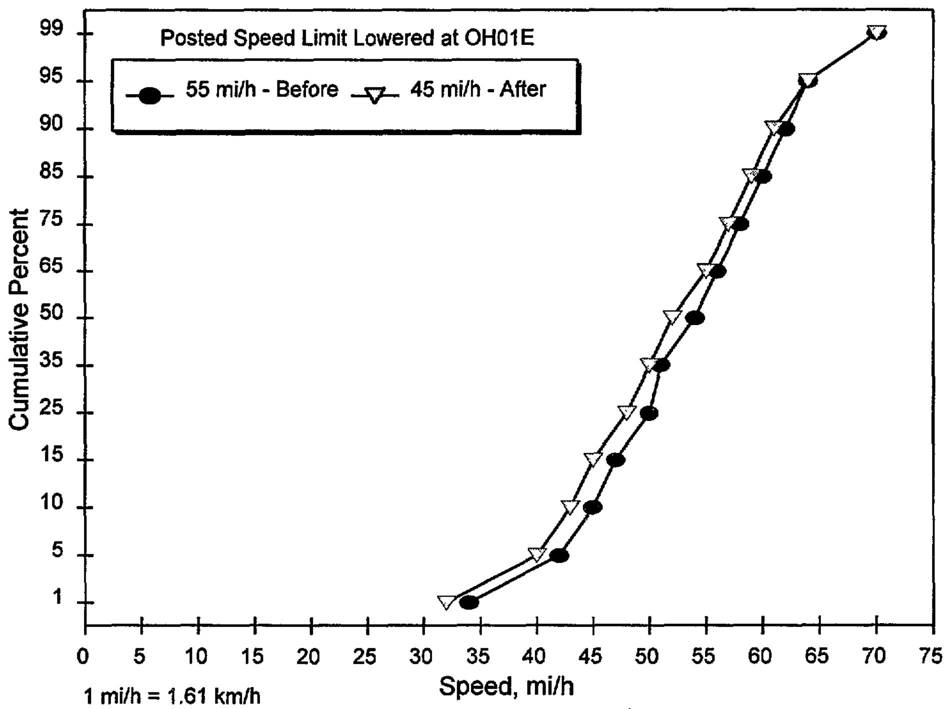


Figure 14. Before and after cumulative speed distributions at an experimental site where the posted speed limit was lowered.

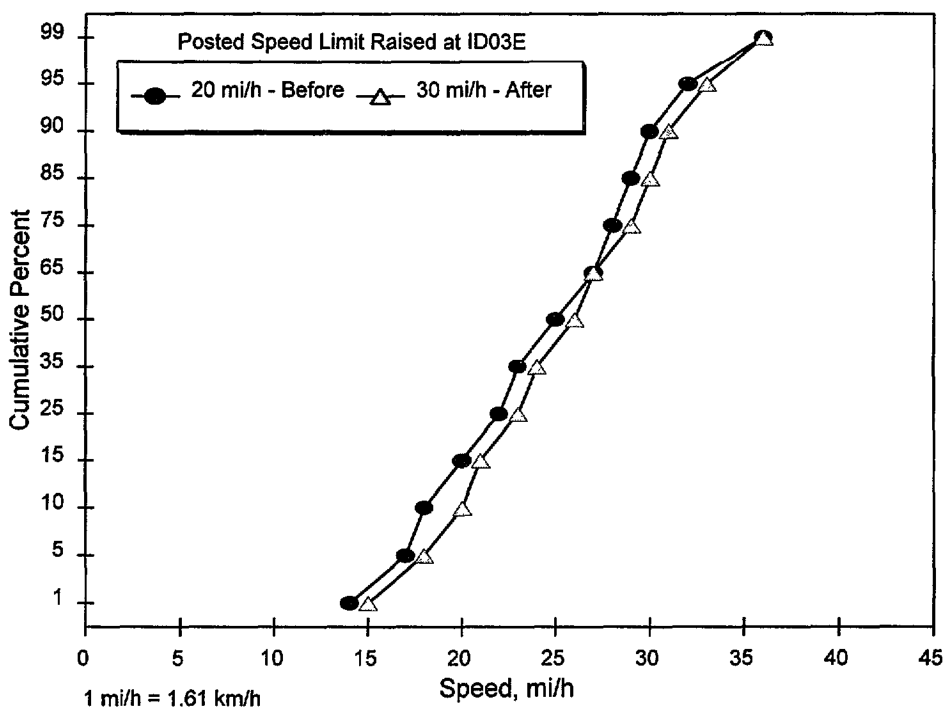


Figure 15. Before and after cumulative speed distributions at an experimental site where the posted speed limit was raised.

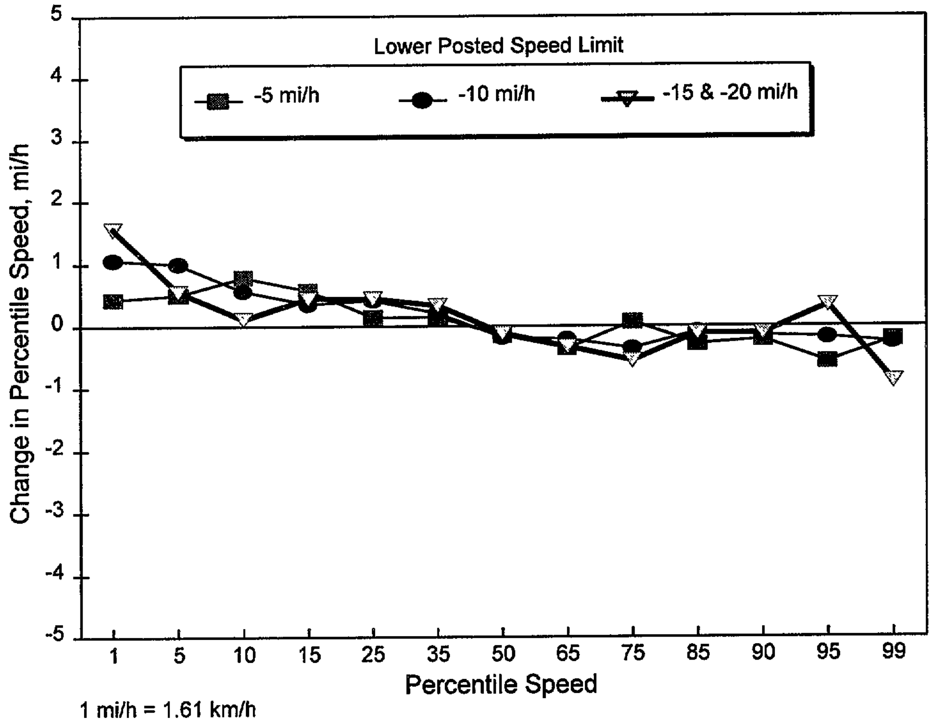


Figure 16. Before and after changes in percentile speeds at the experimental sites where speed limits were lowered.

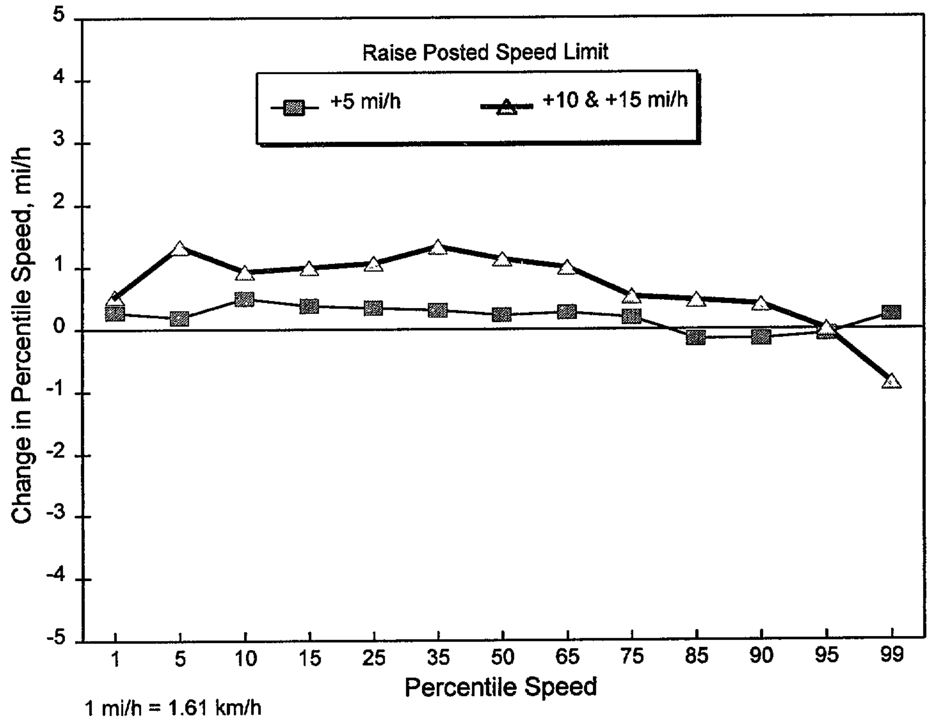


Figure 17. Before and after changes in percentile speeds at the experimental sites where speed limits were raised.

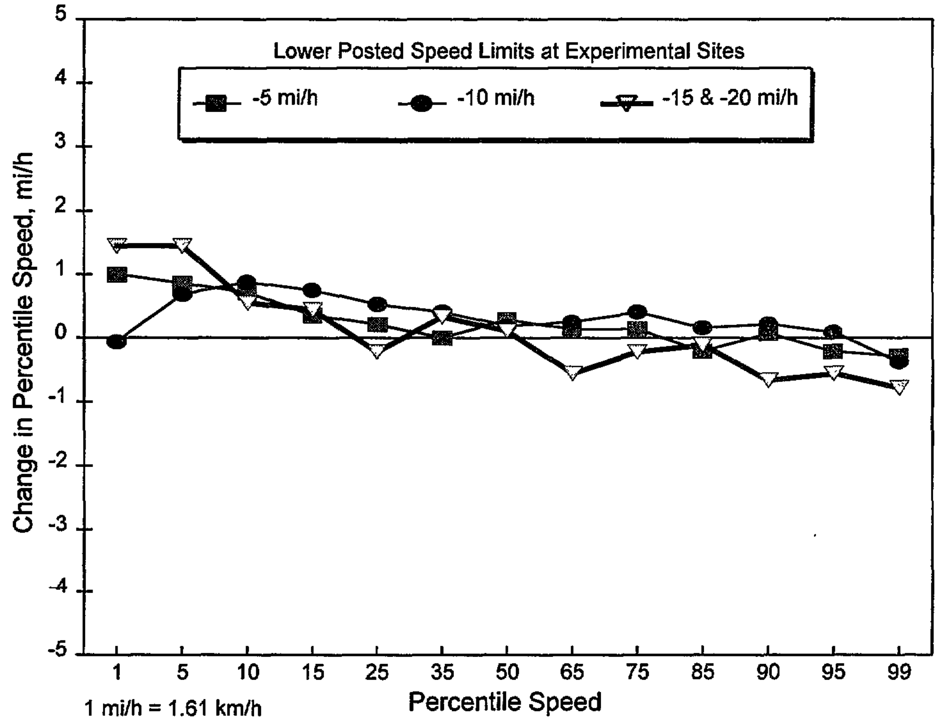


Figure 18. Before and after changes in percentile speeds at the comparison sites corresponding to the experimental sites where speed limits were lowered.

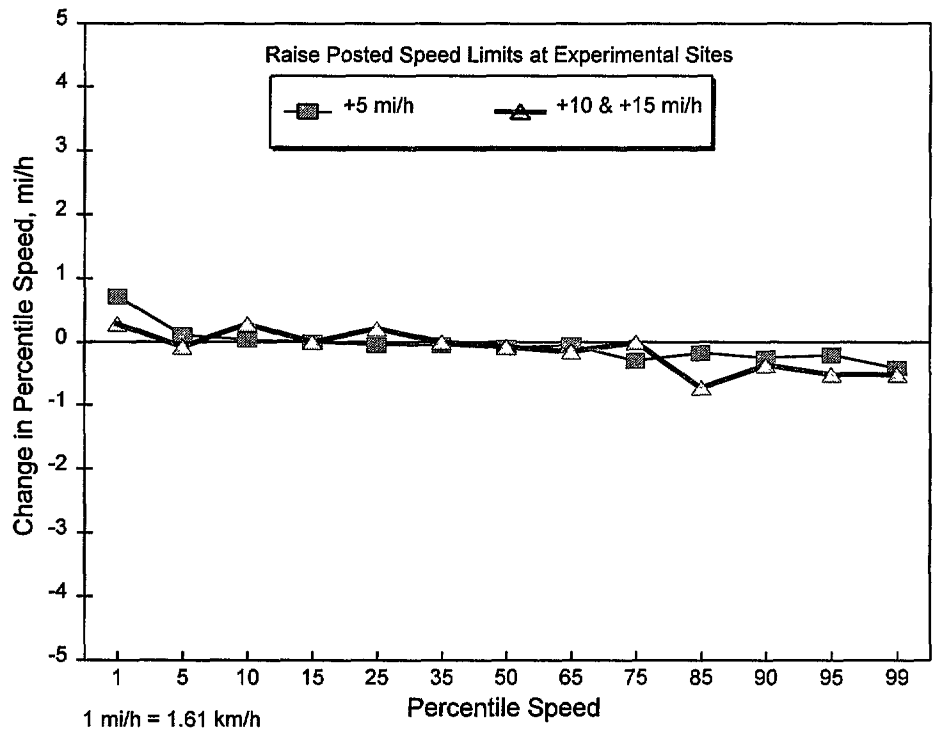


Figure 19. Before and after changes in percentile speeds at the comparison sites corresponding to the experimental sites where speed limits were raised.

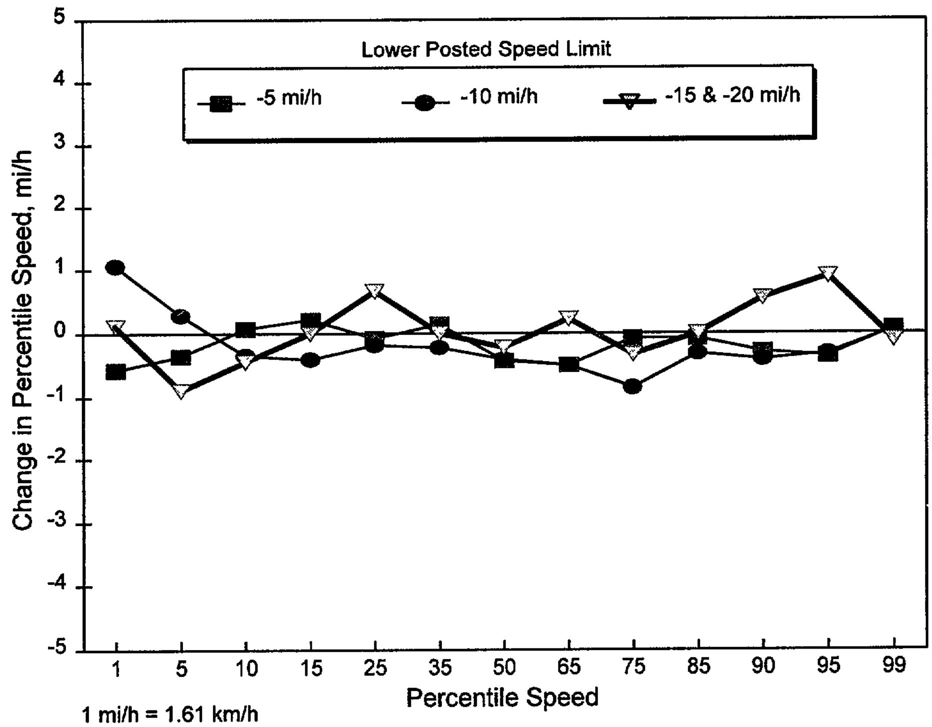


Figure 20. Net change (experimental minus comparison) in percentile speeds at sites where speed limits were lowered.

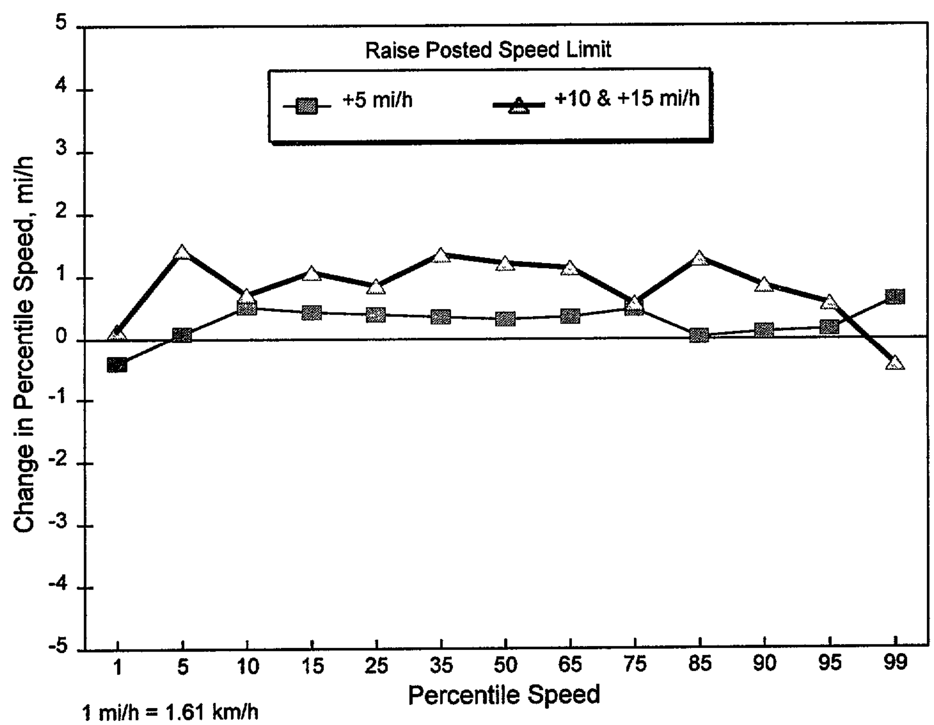


Figure 21. Net change (experimental minus comparison) in percentile speeds at sites where speed limits were raised.

At sites where speed limits were lowered, percentile speeds below the 50th percentile speed tended to increase, and percentile speeds above the 50th percentile speed tended to decrease. However, as shown in figure 18, a similar trend occurred at the comparison sites where the posted speed limits were not changed. The net effects, shown in figure 20, indicate that when speeds were reduced by 10 mi/h (16 km/h), the slowest drivers (1st percentile) increased their speed approximately 1 mi/h (1.6 km/h). There were no changes in the highest speed drivers (99th percentile); however, when speed limits were lowered by 15 or 20 mi/h (24 or 32 km/h), there was approximately a 1-mi/h (1.6-km/h) increase in the 95th percentile speed.

At sites where posted speed limits were raised, generally there was a small increase in speeds below the 75th percentile (less than 1.5 mi/h (2.4 km/h)). The net effects, shown in figure 21, indicate that there was a small decrease in the 99th percentile speed when speed limits were raised by IO or 15 mi/h (16 or 24 km/h).

As described in the Methodology section of the report, the comparison sites were not selected from the same source as the experimental sites. Consequently, the net effects mentioned above may be biased. Even if one excludes the comparison site data altogether, the findings for the experimental groups remain unchanged.

Other measures of the distribution of vehicle speeds include the standard deviation of speeds, the percentage of vehicles in the 10-mi/h (16-km/h) pace, and the skewness index. These data are given in appendix B for each experimental and comparison site.

For the experimental site groups examined in this study, there was a general reduction in the standard deviation of speeds, ranging from 0.1 to 0.3 mi/h (0.16 to 0.5 km/h), irrespective of whether speed limits were raised or lowered. In addition, the percentage of vehicles in the 10-mi/h (16-km/h) pace increased by approximately 2 percent for all posted speed limit groups. There was very little change in the skewness index.

In order to compare speed variations between groups of sites with different speed zones, the coefficient of variation (the standard deviation of speeds divided by the mean speed) was calculated for each speed limit group. Generally, the coefficient of variation decreased by 1 percent for all speed groups, which implies that the distribution of speeds decreased slightly after the speed limits were altered.

It should be noted that statistical tests (i.e., t-test for means, f-test for variance, or Kolomogorov-Smirnow for shifts in distribution), applied to any of the datasets, produce statistically significant results. The reason significant results are achieved is based on the fact that data at each site were collected for a 24-h period, which typically produces a large sample. When the data are combined for groups of speed limit changes, the samples are very large. With the large samples used in this dataset, the statistical tests always indicate that the results are highly significant. Consequently, changes such as 1mi/h (1.6 km/h), as mentioned above, are statistically significant, but not practically meaningful.

Resurfaced Sections

Throughout the site selection process, the researchers coordinated efforts with the participating transportation agencies to ensure that a change in posted speed limit was the only change contemplated at the experimental sites. However, because the study was conducted over several years, the agencies could not guarantee that other changes would not be made.

As the data collectors were preparing to collect after data, they reported that a bituminous concrete riding surface had been applied to four of the experimental sections after the posted speed limits were raised. None of the experimental sites where speed limits were lowered or comparison sites in the study were resurfaced. Because improvements in riding quality may increase vehicle speeds, the first thought was to eliminate the sections from the study. After reconsideration, it was decided to collect the after data and examine the differences in speed. It should be noted, however, that the experimental sections discussed below received both a posted speed limit change and a new pavement surface; consequently, it is not possible to determine if the speed differences are due to the new speed limit, the resurfaced pavement, or both.

The sections resurfaced include MD04E, a 5.83-mi (9.39-km) rural two-lane roadway in Maryland where the speed limit was raised from 50 to 55 mi/h (81 to 89 km/h). Two sites in Brandon, Mississippi, a small urban area (population between 5,000 and 50,000 persons), were also resurfaced. MS01 E is a 0.43-mi (0.69-km) two-lane section that transitions from a rural to an urban area. The speed limit on the section was raised from 35 to 45 mi/h (56 to 72 km/h). MS02E is a 0.68-mi (1.09-km) two-lane urban section where the limit was raised from 30 to 35 mi/h (48 to 56 km/h). In Tennessee, TN01 E is a 6.16-mi (9.92-km) rural four-lane divided highway where the speed limit was raised from 50 to 55 mi/h (81 to 89 km/h).

The before and after differences in speed characteristics for the four resurfaced sections are shown in table 7. The speed data for their corresponding comparison sites are shown in table 8.

Examination of the speed data shown in table 7 indicates that at the two rural long sections (MD04E and TN01E), the speed changes were minor, i.e., generally less than 1 mi/h (1.6 km/h).

At the two small urban area sites (MS01E and MS02E), the 85th percentile speeds increased by 3 mi/h (4.8 km/h). There was a corresponding increase in the mean speed at these locations, as well as a general increase in speeds through the speed distribution. These changes are statistically significant. The changes in speed at the corresponding comparison sites do not reflect a general increase in speeds in the area. The increase in speeds at these locations are among the largest recorded in the study; however, there were several other locations (i.e., IN02E, VA02E, and VA07E) that had similar changes in before and after speeds, but were not resurfaced.

Table 7. Differences in speed characteristics for the resurfaced experimental sites.

Experimental Site Number	Diff. Limit	Mean Speed	Std. Dev. Speeds	Total Volume	Free-Flow Volume	Pct. Free Flow	Percentile Speeds (1 5 10 15 25 35 50 65 75 85 90 95 99)	10-mi/h Lower Limit	10-mi/h Upper Limit
MD04E	5	0.3	0.5	1,060	710	-5.5	4 - 1 0 0 0 0 0 1 0 1 0 1 0	0	
MS01E	10	3.9	-0.3	727	484	-0.9	- 2 4 4 5 5 5 4 5 3 3 3 2 1	5	
MSO2E	5	1.9	0.7	119	233	1.8	2 - 1 0 0 2 2 3 3 2 3 2 2 2	3	
TN01E	5	0.0	-0.1	1,185	880	-1.5	1 0 0 1 1 0 0 0 0 0 0 0 0	1	

1 mi/h = 1.61 km/h
Note: All speed limits and vehicle speeds are shown in mi/h.

Table 8. Differences in speed characteristics for the corresponding comparison sites.

Comparison Site Number	Diff. Limit	Mean Speed	Std. Dev. Speeds	Total Volume	Free-Flow Volume	Pct. Free Flow	Percentile Speeds (1 5 10 15 25 35 50 65 75 85 90 95 99)	10-mi/h Lower Limit	10-mi/h Upper Limit
MD04C	50	1.4	0.1	182	155	-1.3	-1 0 1 1 1 3 2 1 1 2 1 0 2	2	
MS01C	35	1.4	-0.2	496	412	-1.1	4 2 2 1 1 1 1 1 2 1 2 1 3	1	
MS02C	30	0.1	-0.3	247	259	0.9	10 0 0 0 0 0 0 0 0 0 0 -1 1		
TN01C	55	-0.4	0.0	498	422	-2.1	1 0 0 -1 -1 0 -1 0 0 -1 0 0 -1	-1	-1

1 mi/h = 1.61 km/h
Note: All speed limits and vehicle speeds are shown in mi/h.

As before and after pavement roughness information was not available for any of the sites, it is not known if the riding quality significantly changed after the sections were resurfaced.

As the sample of sites is small, no conclusions concerning the effects of resurfacing and raising posted speed limits can be drawn from this data set.

85th Percentile Speed and Posted Speed Limits

The 85th percentile speed is used as one factor in determining the numerical value of the speed limit to post by all State and most local transportation agencies.[3] As previously shown in figure 6, after the posted limits were changed on the experimental sections, the limits posted typically ranged from 5 to 16 mi/h (8 to 26 km/h) below the 85th percentile speed. Some sites, however, had speed limits set within 5 mi/h (8 km/h) of the 85th percentile speed.

The data collected for this study provide an opportunity to examine changes in vehicle speeds when speed limits are posted within 5 mi/h (8 km/h) of the 85th percentile speed versus changes in speeds when limits are set at more than 5 mi/h (8 km/h) below the 85th percentile speed.

Examination of the data revealed that 34.experimental sites had speed limits set within 5 mi/h (8 km/h) of the 85th percentile speed before the new speed limits were posted. Posted speed limits on the 34 sections were lowered more than 5 mi/h (8 km/h) below the 85th percentile speed, i.e., the after speed limits were posted from 6 to 17 mi/h (10 to 27 km/h) below the 85 percentile speed on these sections.

At 21 other experimental sites, the before posted speed limit was more than 5 mi/h (8 km/h) below the 85th percentile speed. At these locations, the before speed limit ranged from 6 to 20 mi/h (10 to 32 km/h) below the 85th percentile speed. The speed limits on these sections were raised to within 5 mi/h (8 km/h) of the 85th percentile speed.

The before and after differences in speed characteristics for the 34 sites where the speed limits were lowered more than 5 mi/h (8 km/h) below the 85th percentile speed are shown in table 9. The data for the 21 sites where speed limits were raised to within 5 mi/h (8 km/h) of the 85th percentile speed are given in table 10.

Similar to the results of other analyses, the differences in the before and after speeds at the sites were typically less than 2 mi/h (3 km/h), regardless of whether the . posted limit was lowered more than 5 mi/h (8 km/h) below the 85th percentile speed or raised to within 5 mi/h (8 km/h) of the 85th percentile speed.

Table 9. Differences in speed characteristics at sites where speed limits were lowered more than 5 mi/h (8 km/h) below the 85th percentile speed.

Experimental Site Number	Diff. Limit	Mean speed	Std. Dev. Speeds	Percentile Speeds 1	5	10	15	25	35	50	65	75	85	90	95	99	10-mi/h Pace Lower Limit	Upper Limit
DEO2E	-15	-0.8	-0.2	2	-1	-1	0	0	0	-1	-1	-2	-1	-1	0	-2	-2	-2
NM01E	-15	0.7	-0.5	0	2	2	3	2	1	0	-1	-1	-1	0	2	3	-3	-3
NM03E	-15	-0.9	0.2	-1	-2	-2	-2	-1	0	-1	-2	-1	0	0	-1	-2	-1	-1
TX05E	-15	-0.4	-0.2	1	1	0	0	0	-1	0	0	-1	-1	-1	0	-1	-1	-1
DE03E	-10	0.1	-0.1	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0
IL01E	-10	-0.7	0.4	-1	0	0	0	0	0	-1	-1	-1	-1	-1	-1	-2	-1	-1
IN01 E	-10	-0.2	-0.2	0	1	0	0	0	0	-1	-1	0	0	0	0	0	0	0
ME02E	-10	0.4	0.0	1	1	1	0	0	0	0	1	1	1	2	1	0	-2	-2
MI09E	-10	0.8	-0.9	2	3	3	3	2	1	0	0	-1	0	0	0	-1	-1	-1
NJ02E	-10	0.0	-1.0	2	2	1	1	1	1	0	0	-1	0	-1	-1	-2	0	0
NJ03E	-10	0.5	-0.5	-6	4	3	2	1	0	0	0	0	0	-1	-1	-1	0	0
OH01E	-10	-1.3	04	-2	-2	-2	-2	-2	-1	-2	-1	-1	-1	-1	0	0	-2	-2
OH03E	-10	0.4	-0.1	1	1	0	0	0	0	0	0	0	0	0	-1	2	0	0
OH04E	-10	-0.7	-0.3	1	0	0	0	-1	-1	-1	-1	-1	-1	0	0	0	-2	-2
OH05E	-10	0.1	-1.0	6	3	0	1	1	0	-1	-1	-1	0	0	0	0	-1	-1
OH06E	-10	0 5	-0.9	5	2	2	1	1	0	0	-1	-1	0	1	0	-1	-2	-2
OH10E	-10	-20	-0.5	0	-1	-2	-1	-1	-2	-2	-3	-2	-2	-2	-3	-3	-2	-2
OH11E	-10	1.9	-2.1	2	3	4	5	9	3	1	0	-1	0	0	-1	-1	-1	-1
OH12E	-10	-1.3	0.1	2	-1	-1	-1	-2	-2	-2	-1	-2	-1	-2	0	1	-2	-2
OK01E	-10	-0.4	0.2	-1	-2	0	0	0	0	0	-1	-1	0	0	0	1	-2	-2
OK02E	-10	0.4	- 0 3	2	1	0	0	1	0	0	0	0	1	0	0	0	0	0
OKO4E	-10	-0.4	0.7	-3	-2	-1	-1	-1	0	0	0	0	0	0	0	1	0	0
TX02E	-10	-0.9	-0.6	2	0	0	-1	-1	-1	-1	-1	-1	-1	-2	-1	-1	-2	-2
VA01 E	-10	-0.9	-0.6	1	1	0	0	-1	-1	-1	-1	-2	-2	-1	-1	-1	-2	-2
VA03E	-10	0.8	-0.2	1	1	1	1	1	1	0	0	0	1	0	0	-1	1	1
VA05E	-10	0.2	-0.8	1	4	1	0	1	1	0	0	0	-1	-1	-1	0	3	3
VAO7E	-10	2.4	-0.6	4	3	4	3	3	2	3	2	1	2	2	2	1	2	2
CT02E	-5	0.0	-0.1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
CT05E	-5	1.0	-0.1	1	1	2	1	1	1	1	1	1	1	1	1	1	0	0
ID02E	-5	0.4	-0.3	1	1	1	1	0	1	1	0	1	1	-1	-1	-1	2	2
IN05E	-5	-0.6	-0.4	1	0	0	0	0	0	-1	-1	-1	-1	-1	-1	-1	1	1
IN08E	-5	-0.4	-0.6	0	1	1	1	-1	0	-1	-1	0	-1	-1	-1	-1	-1	-1
IN07E	-5	0.6	- 0 1	1	1	1	1	1	1	0	0	1	1	1	0	2	0	0
NJ01E	-5	0.4	0.0	0	0	1	0	0	0	0	0	1	0		0	0	0	0
34 Sites	Mean Diff.	-0.01	-0.35	0.76	0.76	0.59	0.50	0.41	0.15	-0.29	-0.44	-0.47	-0.21	-0.26	-0.26	-0.29	-0.62	-0.6

1 mi/h = 1.61 km/h
Note: All speed limits and vehicle speeds are shown in mi/h.

Table 10. Differences in speed characteristics at sites where speed limits were raised to within 5 mi/h (8 km/h) of the 85th percentile speed.

Experimental Site Number	Diff. Limit	Mean Speed	Std. Dev. Speeds	Percentile Speeds 1	5	10	15	25	35	50	65	75	85	90	95	99	10-mi/h Pace Lower Limit	Upper Limit	Pct. Pace	Skew. Index
AZ03E	5	1.0	-0.9	3	2	2	2	1	1	1	1	1	-1	0	0	-1	1	1	9.6	0.01
CA06E	5	-2.1	-0.2	-1	-2	-1	-2	-2	-2	-2	-2	-2	-3	-3	-3	-2	-2	-2	2.2	-0.05
CO03E	5	-0.5	-0.3	1	0	-1	-1	-1	0	0	0	0	-1	-2	-3	0	2	2	-2.7	-0.19
IN02E	5	-2.8	-0.2	0	-1	-2	-2	-3	-4	-4	-3	-3	-3	-3	-3	-2	-3	-3	-2.1	0.18
IN03E	5	-0.4	0.0	-1	-1	-1	0	-1	0	0	-1	0	-1	-1	-1	-1	-1	-1	0.4	-0.07
MD02E	5	0.9	-0.1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	2.4	-0.07
MD03E	5	-0.1	0.3	-1	-1	-1	0	0	0	0	0	0	0	0	0	0	0	0	-0.6	-0.04
MD08E	5	2.4	0.4	0	1	2	3	2	3	3	3	2	2	3	3	3	3	3	1.2	-0.16
MD10E	5	0.5	0.0	1	0	1	0	1	0	1	1	1	0	1	0	0	0	0	-0.2	0.00
TX06E	5	0.3	-0.5	1	1	2	1	1	1	0	0	0	-1	-1	0	0	0	0	5.5	0.09
TX08E	5	1.9	-0.1	1	2	3	2	2	2	2	2	2	1	2	1	1	2	2	1.9	0.00
ID03E	10	0.8	-0.4	1	1	2	1	1	1	1	0	1	1	1	1	0	1	1	3.3	-0.01
ID04E	10	1.0	-0.4	1	2	2	2	1	1	1	1	0	1	1	1	-1	0	0	3.3	0.04
ID05E	10	-0.2	-1.0	1	1	0	1	1	1	0	0	-1	-1	-1	-1	-4	-1	-1	3.4	-0.06
ID06E	10	1.6	0.6	0	0	-1	1	2	2	2	3	3	2	2	2	0	2	2	-2.2	-0.13
ID07E	10	0.8	0.6	-1	-1	-1	0	1	1	1	1	1	2	2	1	1	1	1	-7.1	-0.05
ID08E	10	1.8	-0.5	1	2	2	2	2	3	3	2	2	1	1	0	1	3	3	4.0	-0.25
VA02E	10	3.1	0.0	2	4	3	4	3	4	3	3	3	2	3	3	5	3	3	1.9	0.00
CA04E	15	-1.4	-0.4	-2	0	-1	-2	-1	-1	-2	-2	-2	-2	-2	-2	-3	-1	-1	3.1	0.07
IN04E	15	1.3	-0.7	2	2	3	2	1	1	2	2	0	0	-1	-2	-2	1	1	5.4	-0.14
TX01E	15	-1.5	-0.9	2	2	-1	-2	-2	-1	-1	-2	-2	-1	-1	-2	-8	-2	-2	0.1	-0.08
21 Sites	Mean Diff.	0.40	-0.22	0.57	0.71	0.62	0.62	0.48	0.67	0.57	0.48	0.33	-0.05	0.10	-0.24	-0.57	0.48	0.48	1.56	-0.04

1 mi/h = 1.61 km/h
Note: All speed limits and vehicle speeds are shown in mi/h.

The mean differences in the before and after percentile speeds were calculated for both groups of sites and the results are presented graphically in figures 22 and 23. As shown in figure 22, for the group of 34 sites where speed limits were lowered more than 5 mi/h (8 km/h) below the 85th percentile speed, there was a small increase-less than 1 mi/h (1.6 km/h)-in speed below the 50th percentile. For this group of sites, there was a small decrease-less than 1 mi/h (1.6 km/h)-in speeds above the 50th percentile.

As shown in figure 23, there was a small increase-less than 1 mi/h (1.6 km/h)-in speeds below the 85th percentile speed for the group of 21 sites where speed limits were raised to within 5 mi/h (8 km/h) of the 85th percentile speed. For this group, there was a small decrease in speeds above the 85th percentile speed.

These data suggest that there is a statistically significant difference in free-flow vehicle speeds when posted limits are set more than 5 mi/h (8 km/h) below the 85th percentile speed or within 5 mi/h of the 85th percentile speed; however, for the sites selected in this study, the difference was less than 1mi/h (1.6 km/h).

Effects on Driver Compliance

Driver compliance with a posted speed limit is defined as the percentage of vehicles traveling at or below the posted limit. For example, if 75 percent of the drivers sampled in a 50-mi/h (81-km/h) posted speed zone are traveling at or below 50 mi/h (81 km/h), then driver compliance would be reported as 75 percent. Traffic engineering and enforcement officials have not defined specific numerical thresholds for acceptable driver compliance.

Average driver compliance with speed limits for the group of 57 experimental sites, before the speed limits were lowered, is shown in figure 24 for posted speed limits ranging from 30 to 55 mi/h (48 to 89 km/h). Generally, driver compliance could be considered as acceptable for limits posted at 45 mi/h (72 km/h) or greater. However, for sections where the posted limits were less than 45 mi/h (72 km/h), driver compliance was poor. As shown in figure 25, average driver compliance at the 41 experimental sites, before the speed limits were raised, was very poor for all posted limits.

Average driver compliance for the group of comparison sites, where posted speed limits were not changed, is shown in figure 26. At limits posted below 55 mi/h (89 km/h), driver compliance at these locations was also poor.

As noted in the previous section on speed effects, most drivers at the study sites did not make major alterations in their speed after the new speed limits were posted. It appears that the new posted speed limits alone, without some additional engineering, enforcement, or educational measures, did not have a major effect on driver behavior or encourage most drivers to comply with the posted speed limit. In the remaining discussion on driver compliance, it is important to realize that the before and after changes mentioned are basically attributable to the way compliance is measured (i.e., from the posted speed limit) and not to actual changes in driver behavior.

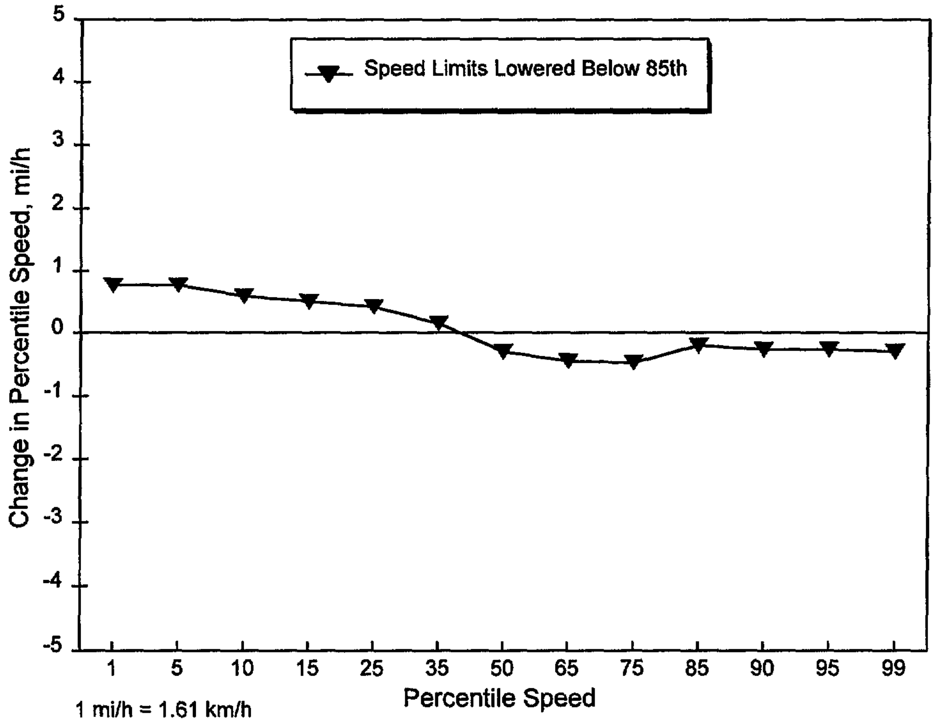


Figure 22. Mean change in percentile speeds at 34 sites where speed limits were lowered below the 85th percentile speed.

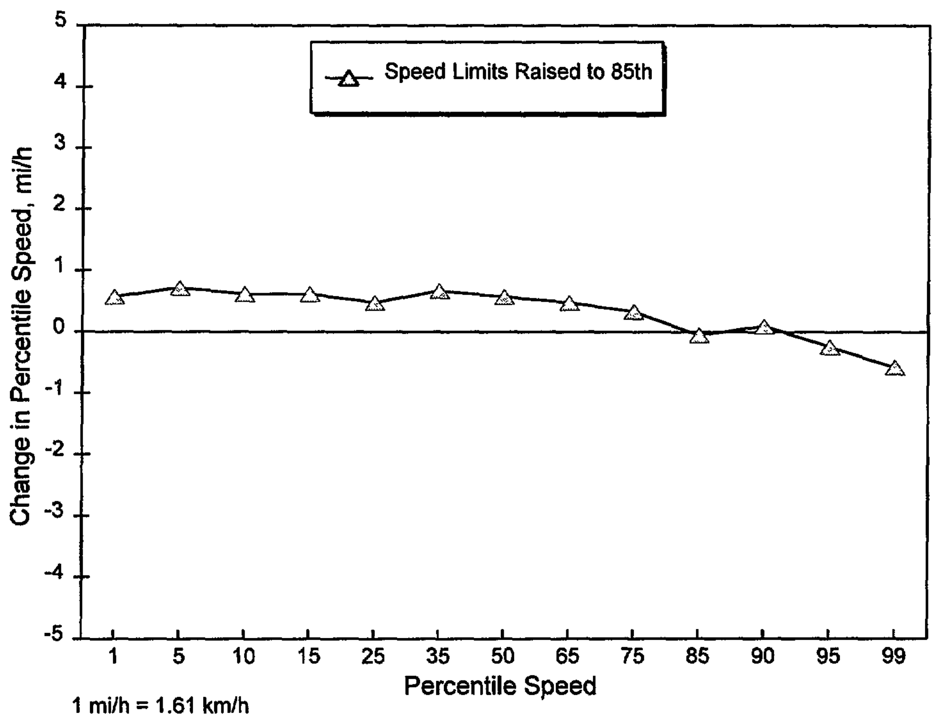


Figure 23. Mean change in percentile speeds at 21 sites where speed limits were raised to the 85th percentile speed.

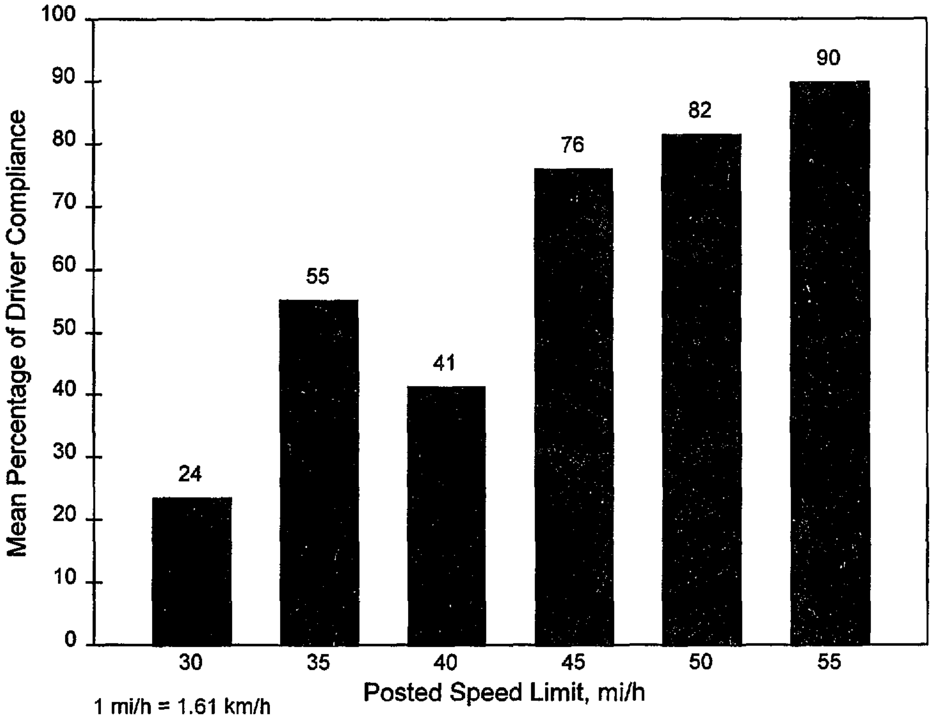


Figure 24. Average driver compliance at 57 experimental sites before the speed limits were lowered.

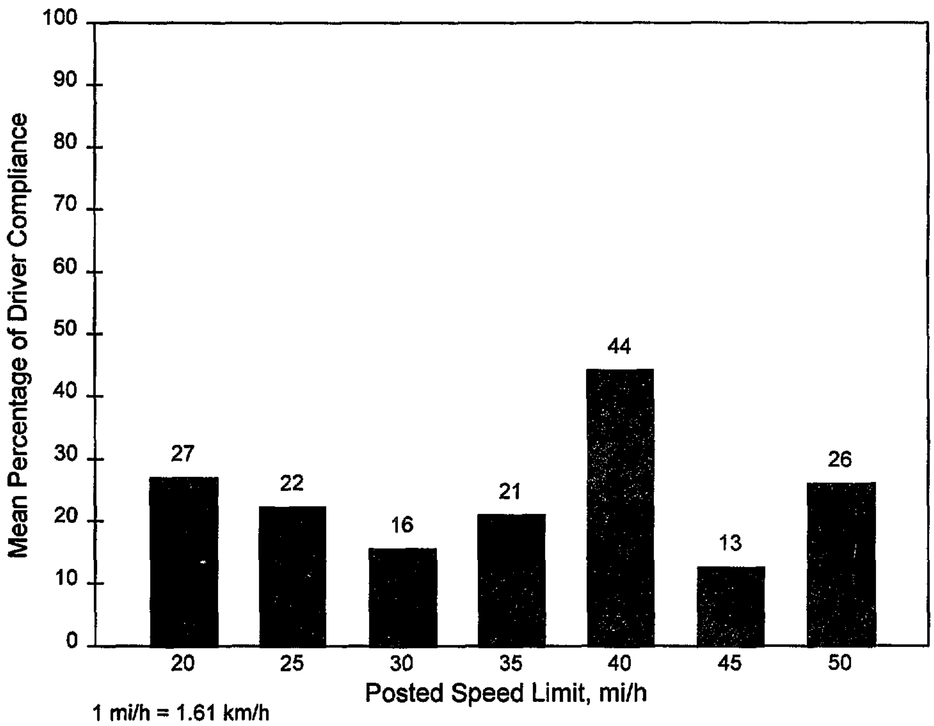


Figure 25. Average driver compliance at 41 experimental sites before the speed limits were raised.

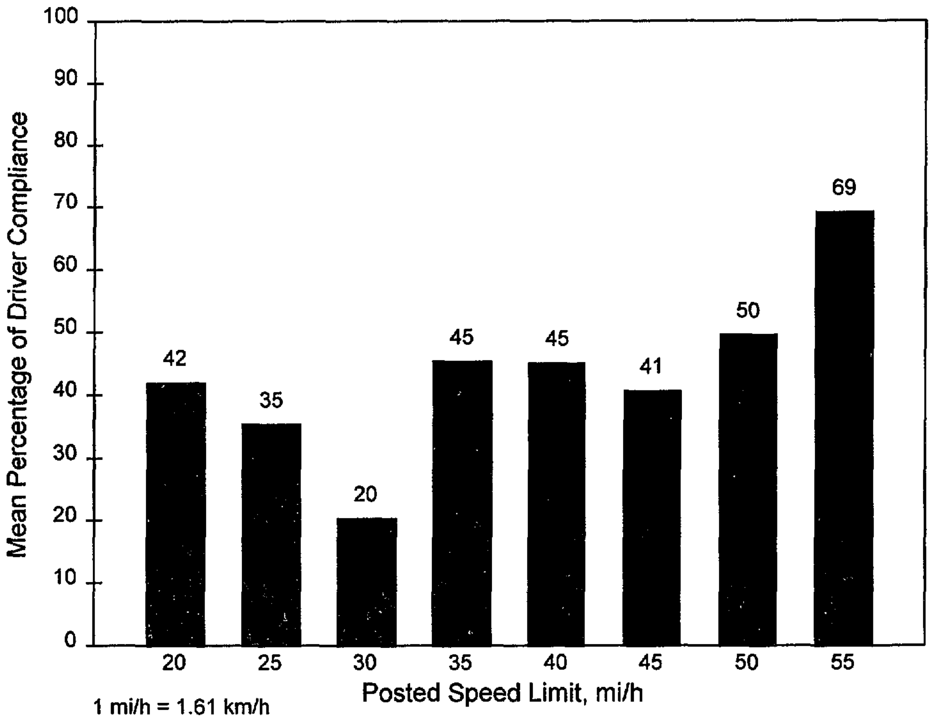


Figure 26. Average driver compliance at the comparison sites.

The mean change in driver compliance, after speed limit alterations were made at the experimental sites, is shown in figure 27 for the speed limit change groups. For the group of sites where the speed limits were lowered by 15 or 20 mi/h (24 or 32 km/h), average compliance decreased by two-thirds. At sites where speed limits were lowered by 10 mi/h (16 km/h), there was approximately a 50 percent reduction in compliance. The majority of drivers, for whatever reasons, apparently did not choose to comply with the new, lower speed limits at these sites.

Conversely, at the group of sites where speed limits were raised by 10 or 15 mi/h (16 or 24 km/h), there was a fourfold increase in driver compliance. Even at this level, however, only about two-thirds of the motorists drove at or below the posted speed limits. Again, it should be noted that these figures do not reflect a change in driver behavior to comply with the new limits, but a change in the standard used to measure compliance, i.e., the posted speed limit.

Noncompliance with a posted speed limit, as measured by the percentage of drivers who exceed the speed limit by various amounts, has also been used to describe driver behavior. Shown in table 11 is a summary of the mean percentage of drivers exceeding the speed limit by 0, 5, 10, 15, or 20 mi/h (0, 8, 16, 24, or 32 km/h) at the experimental sites for each speed limit change group.

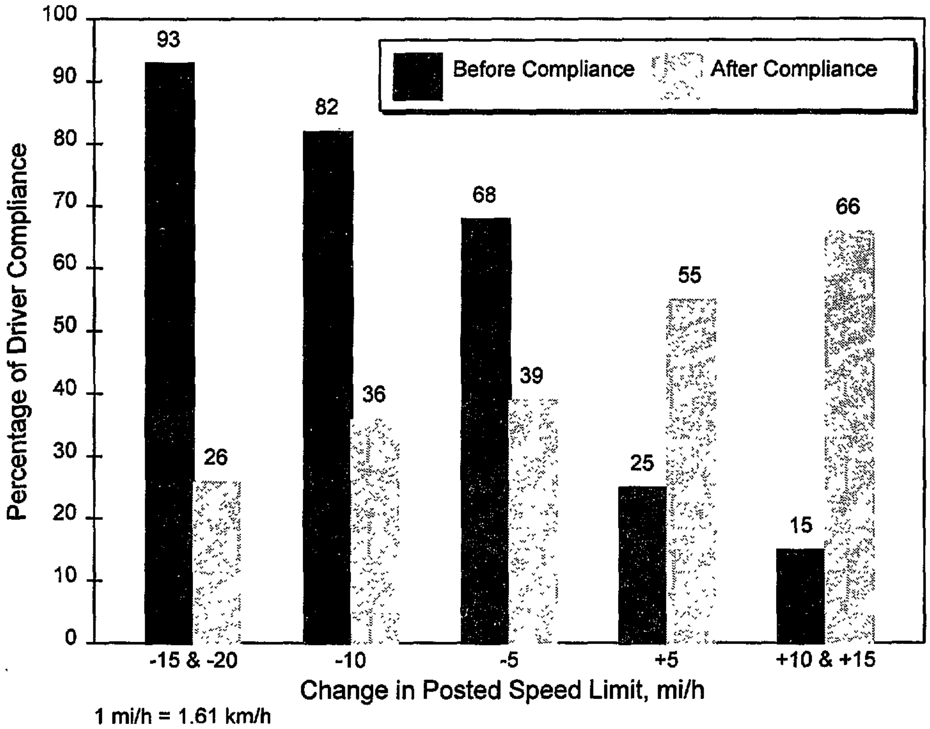


Figure 27. Driver compliance before and after speed limits were changed at the experimental sites.

As with driver compliance, when the limits were lowered, a greater percentage of drivers exceeded the new limits. When speed limits were raised, more drivers were in compliance with the speed limits. Again, these figures do not represent a shift in driver behavior, but a change in how noncompliance is measured, i.e., from the posted speed limit.

As shown in table 12, the mean change in driver compliance between the before and after periods for the comparison site groups where speed limits were not altered was less than 1.6 percent.

There was considerable variation in the percentages from site to site, depending upon the level of the speed limit change. Individual site data for the experimental and comparison sites are given in appendix C.

Overall, altering the speed limits at the experimental sites had a dramatic effect on driver compliance, but most of the effect was due to how compliance was measured, i.e., percentage of motorists driving at or below the posted speed limit. Changing the speed limit did not alter driver behavior. After the speed limits were lowered, driver compliance was typically less than 40 percent at the study sites. At sites where speed limits were raised, compliance was generally less than 60 percent.

Table 11. Percentage of drivers exceeding posted speed limits at the experimental sites.

Change in Posted Speed Limit		Before: Percent Exceeding Posted Speed Limit 0	5	10	15	20	After: Percent Exceeding Posted Speed Limit 0	5	10	15	20	Differences: Percent Exceeding Posted Speed Limit 0	5	10	15	20
-15 & -20	9 sites	6.6	2.0	0.4	0.0	0.0	74.1	47.3	21.2	6.4	1.8	67.5	45.3	20.8	6.4	1.8
-10	34 sites	18.2	6.5	1.7	0.3	0.0	64.3	37.3	17.2	6.3	1.8	46.1	30.8	15.5	6.0	1.7
-5	14 sites	32.2	12.8	4.4	1.4	0.5	60.9	31.7	12.5	4.3	1.4	28.7	18.9	8.1	2.9	0.9
+5	26 sites	74.6	45.9	20.3	7.1	2.0	44.9	19.2	6.6	1.9	0.5	-29.7	-26.7	-13.7	-5.2	-1.5
-10 & +15	15 sites	84.9	60.6	34.5	16.0	5.7	33.8	12.9	3.6	0.7	0.2	-51.1	-47.6	-31.0	-15.2	-5.5

1 mi/h = 1.61 km/h
Note: All speed limits are shown in mi/h.

Table 12. Percentage of drivers exceeding posted speed limits at the comparison sites.

Change in Posted Speed Limit at Experimental Sites		Before: Percent Exceeding Posted Speed Limit 0	5	10	15	20	After: Percent Exceeding Posted Speed Limit 0	5	10	15	20	Differences: Percent Exceeding Posted Speed Limit 0	5	10	15	20
-15 &-20	9 sites	34.9	17.6	7.1	3.0	1.0	34.8	16.6	6.6	2.2	0.6	-0.1	-1.0	-0.5	-0.8	-0.4
-10	32 sites	37.8	16.9	5.5	1.4	0.3	39.4	17.3	5.4	1.3	0.2	1.6	0.4	-0.1	-0.1	-0.1
-5	14 sites	52.2	25.4	8.8	2.4	0.5	53.4	26.0	8.7	2.1	0.3	1.2	0.7	-0.1	-0.3	-0.1
+5	25 sites	66.5	36.8	13.9	3.8	0.7	66.0	36.1	13.1	3.4	0.6	-0.5	-0.7	-0.8	-0.3	-0.1
+10 & +15	14 sites	71.0	40.2	17.0	6.2	1.6	71.4	39.7	17.2	6.1	1.6	0.3	-0.5	0.2	-0.1	-0.0

1 mi/h = 1.61 km/h
Note: All speed limits are shown in mi/h.

This study did not measure current enforcement levels or practices in the participating States and jurisdictions. In addition, the study scope did not address methods for achieving compliance with speed limits.

It is well known that the presence of police enforcement has a deterrent effect which tends to improve driver compliance with speed limits. In general, the magnitude of the speed change depends on the speed limit and the perceived deterrent effect. Vehicle speed decreases of 3 to 10 mi/h (5 to 16 km/h) have been observed.[9,17] Other measures, such as educational campaigns combined with police visibility, posting realistic speed limits, speed governors on vehicles, designing roadways for speed management, etc., are also effective in improving driver behavior and compliance with posted speed limits.[18]

Effects on Close Following Behavior

In conjunction with speed data collection, before and after vehicle headway data were collected for a 24-h period at each experimental and comparison site pair. The purpose of collecting these data was to determine if changes occurred in short vehicle headways, defined as headways less than 2 s.

Vehicle headways on a roadway are a function of traffic flow, i.e., the mean headway decreases with increasing volume. It is only appropriate to compare differences in headways when traffic volumes at the sites are similar. Prior to conducting the headway analysis, a comparison was made of the before and after 24-h traffic volumes recorded at each site. For the purpose of this analysis, it was decided to include experimental sections where traffic volumes had changed less than 10 percent during the before and after periods. Shown in table 13 are the 24-h traffic volumes and short headway data for sections where posted speed limits were lowered. Similar data are shown in table 14 for sites where posted speed limits were raised.

As shown in tables 13 and 14, the before and after differences in short headways were small for both the raised and lowered speed limit sites. Chi-square tests indicated no statistically significant differences in the proportion of short headways at these sites.

Shown in figures 28 and 29 are before and after headway distributions for a low-volume and a high-volume experimental site where the posted speed limits were lowered. Figures 30 and 31 show before and after headway distributions for a low-volume and a high-volume experimental site where the posted speed limits were raised. These figures illustrate that there was little change in short headways and in the distribution of headways of 10 s or less at these sites, irrespective of whether the speed limits were raised or lowered.

Table 13. Before and after short headway data for 28 experimental sites where posted speed limits were lowered.

Site Number	Before Speed Limit	After Speed Limit	Diff. Limit	Total Before Volume	Before <2 s Volume	Before <2 s Pct.	Total After Volume	After <2 s Volume	After <2 s Pct.
Two-Lane Sites - Lower Speed Limits									
DE02E	50	35	-15	507	13	2.56	529	11	2.08
MA01E	40	30	-10	318	1	0.31	319	4	1.25
ME02E	45	35	-10	405	4	0.99	380	5	1.32
DE04E	50	40	-10	433	4	0.92	413	6	1.45
OH08E	55	45	-10	626	6	0.96	697	5	0.72
OH06E	55	45	-10	1,138	22	1.93	1,051	17	1.62
VAO5E	55	45	-10	1,247	40	3.21	1,230	50	4.07
VA03E	55	45	-10	1,295	47	3.63	1,307	52	3.98
OH11E	50	40	-10	1,391	25	1.80	1,455	23	1.58
TX02E	55	45	-10	2,259	96	4.25	2,412	107	4.44
IN01E	55	45	-10	2,305	87	3.77	2,209	95	4.30
CA01E	35	25	-10	2,553	72	2.82	2,493	78	3.13
VA07E	55	45	-10	4,588	487	10.61	4,305	411	9.55
OK04E	45	35	-10	5,663	700	12.36	5,301	599	11.30
OK03E	35	25	-10	6,322	490	7.75	5,755	420	7.30
NJ02E	45	35	-10	7,328	854	11.65	7,584	994	13.11
OH07E	55	45	-10	7,715	1,026	13.30	8,280	1,084	13.09
VA01E	55	45	-10	8,456	1,227	14.51	8,651	1,325	15.32
DE03E	50	40	-10	9,039	1,835	20.30	9,092	1,839	20.23
OK02E	35	25	-10	11,512	1,000	8.69	11,019	1,063	9.65
ME01 E	45	40	-5	343	1	0.29	333	6	1.80
IN05E	45	40	-5	1,486	49	3.30	1,521	49	3.22
IN07E	50	45	-5	5,745	516	8.98	6,023	602	10.00
AZ01E	50	45	-5	7,979	1,577	19.76	8,083	1,686	20.86
ID02E	55	50	-5	8,155	1,388	17.02	8,270	1,333	16.12
IN06E	50	45	-5	8,563	1,320	15.42	8,770	1,386	15.80
IL02E	50	45	-5	9,542	1,611	16.88	10,420	1,909	18.32
NJ01 E	40	35	-5	12.853	2.777	21.61	12.485	2.921	23.40

1 mi/h = 1.61 km/h
Note: All speed limits are shown in mi/h.

Table 14. Before and after short headway data for 18 experimental sites where posted speed limits were raised.

Site Number	Before Speed Limit	After Speed Limit	Diff. Limit	Total Before Volume	Before <2 s Volume	Before <2 s Pct.	Total After Volume	After <2 s Volume	After <2 s Pct.
Two-Lane Sites - Raise Speed Limits									
DE05E	35	40	5	476	3	0.63	510	7	1.37
AZ02E	25	30	5	1,344	27	2.01	1,367	28	2.05
TX06E	30	35	5	1,619	39	2.41	1,776	21	1.18
CT04E	30	35	5	1,798	87	4.84	1,906	99	5.19
MD07E	30	35	5	2,693	167	6.20	2,770	190	6.86
AZ03E	30	35	5	4,105	248	6.04	4,186	240	5.73
MS02E	30	35	5	7 791	1 065	13.67	7.901	962	12.18
ID04E	20	30	10	1,252	6	0.48	1,322	16	1.21
ID03E	20	30	10	1,490	43	2.89	1,372	26	1.90
CT03E	30	40	10	1,728	74	4.28	1,794	83	4.63
ME03E	35	45	10	1.774	124	6.99	1.819	144	7.92
IN04E	30	45	15	431	5	1.16	476	2	0.42
Four-Lane Divided Sections - Raise Speed Limits									
CA06E	45	50	5	13,003	1,741	13.39	13,049	1,819	13.94
CT01E	45	50	5	19,024	3,750	19.71	19,028	3,884	20.41
Two-lane One-Way Pairs - Raise Speed Limits									
IN02E	25	30	5	8,291	881	10.63	8,688	985	11.34
IN03E	25	30	5	8,768	1,355	15.45	9,229	1,442	15.62
ID06E	25	35	10	8,147	792	9.72	7,879	696	8.83
ID07E	25	35	10	8,124	461	5.67	8,032	391	4.87

1 mi/h = 1.61 km/h
Note: All speed limits are shown in mi/h.

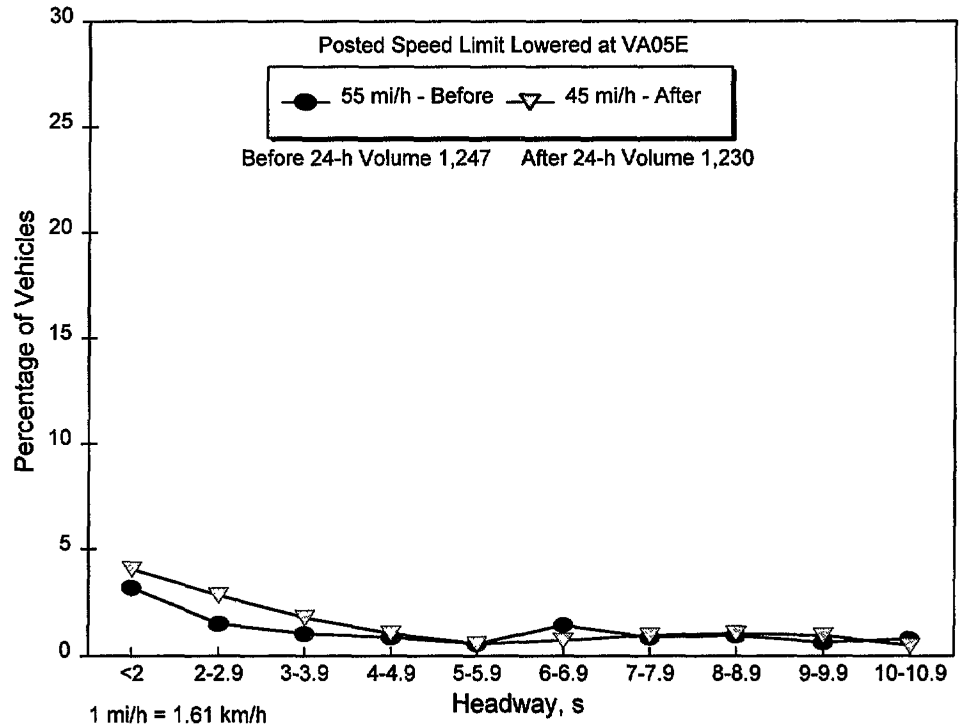


Figure 28. Before and after percent changes in headways at a low-volume experimental site where the speed limit was lowered.

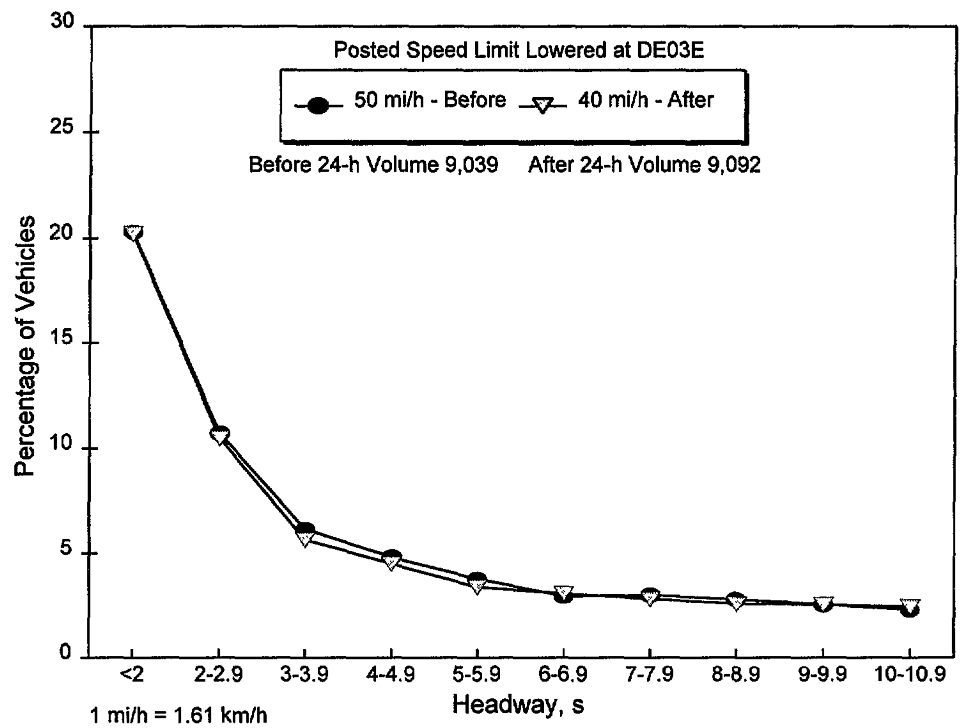


Figure 29. Before and after percent changes in headways at a high-volume experimental site where the speed limit was lowered.

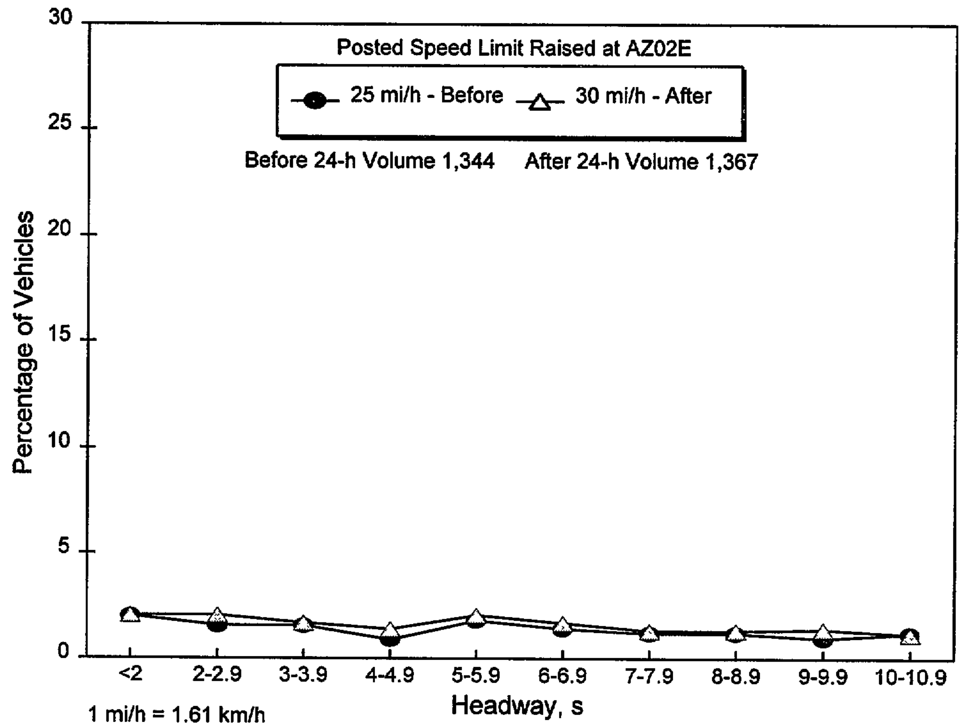


Figure 30. Before and after percent changes in headways at a low-volume experimental site where the speed limit was raised.

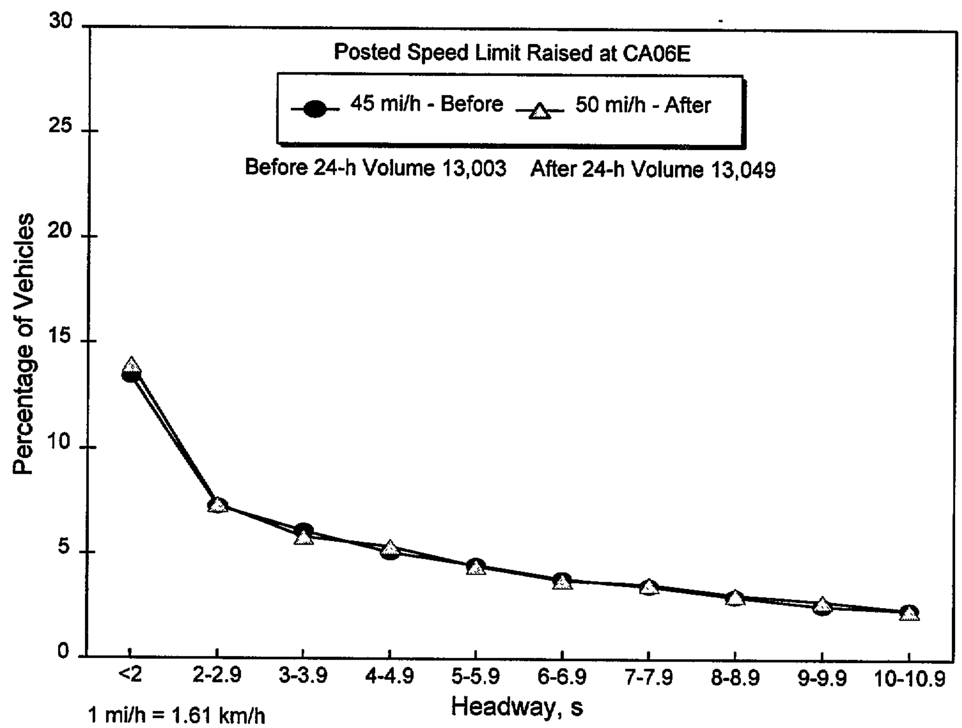


Figure 31. Before and after percent changes in headways at a high-volume experimental site where the speed limit was raised.

Repeated Measurements

The results of speed observations have shown that variations in spot speeds occur over time, even in the absence of speed limit changes or other alterations.[19-21] To obtain some information on the time effects of speed limit alterations, repeated speed measurements were made at 11 experimental and comparison sites.

Posted speed limits on the experimental sites were lowered at five locations and raised at six other sites. Speed data were collected before the speed limits were posted and again after the new limits were posted, at intervals ranging from 1 day to 2 years and 9 months. A summary of the 24-h mean and 85th percentile speeds for the 11 sites is shown in table 15. A detailed summary of the speed measurements for the sites is given in appendix D.

Of the five sites where speed limits were lowered, two locations, OH01 E and OH05E, were on roadways passing through small rural communities. Two other locations, DE01 E and VA05E, were two-lane facilities in rural communities. Site IN07E was a primary route in a small urban area.

As shown in table 15, at four sites where speed measurements were taken within 1 to 3 months after the speed limits were lowered, the 85th percentile speeds increased by 1 mi/h (1.6 km/h) at one site, decreased by 2 mi/h (3.2 km/h) at another site, and remained the same at two locations. One year after the speed limits were lowered, the 85th percentile speeds decreased by 1 mi/h (1.6 km/h) at one site, decreased by 2 mi/h (3.2 km/h) at one site, and remained the same at two sites. At three sites where measurements were taken 2 yr after the speed limits were lowered, 85th percentile speeds decreased by 1 mi/h (1.6 km/h) at two sites, and increased by 1 mi/h (1.6 km/h) at one site.

Of the six sites where speed limits were raised, two locations, MD06E and TX01E, were roadways passing through small rural communities. Sites ID03E and ID04E were urban streets in a city of less than 5,000 persons. The site in Virginia, VA02E, was a two-lane facility in a small urban area. Site MD01E was a rural two-lane roadway where the speed limit was raised from 50 to 55 mi/h (81 to 89 km/h).

At five sites where speed measurements were taken within 1 to 3 months after the speed limits were raised, the 85th percentile speeds increased by 1 mi/h (1.6 km/h) at three sites, increased by 2 mi/h (3.2 km/h) at one site, and remained the same at one site. One year after the speed limits were changed, the 85th percentile speeds increased by 1 mi/h (1.6 km/h) at two locations, increased by 2 mi/h (3.2 km/h) at two sites, and decreased by 3 mi/h (4.8 km/h) at one location. At three sites where measurements were made 2 yr after the speed limits were raised, the 85th percentile speeds increased by 2 mi/h (3.2 km/h) at one location, remained the same at one location, and decreased by 1 mi/h (1.6 km/h) at one location.

Table 15. Repeated speed measurements at 11 experimental sites.

Site Number	Posted Speed Limit mi/h Before	Posted Speed Limit mi/h After	Before Period Collection Date	Before Period Mean mi/h	Before Period 85th mi/h	Date Speed Limit Posted	After Period 1 to 3 months Collection Date	1 to 3 months Mean mi/h	1 to 3 months 85th mi/h	1 yr Collection Date	1 yr Mean mi/h	1 yr 85th mi/h	2 yr or more Collection Date	2 yr or more Mean mi/h	2 yr or more 85th mi/h
Lower Speed Limit Sites															
DE01E	40	35	09-26-86	45.3	54	11-04-86	12-12-86	47.1	55				10-28-88	45.1	53
IN07E	50	45	12-17-86	44.1	51	12-29-86				04-18-88	44.8	51	08-09-88	44.7	52
OH01E	55	45	06-25-86	53.0	60	09-07-86	10-01-86	50.9	58	07-15-87	51.8	58	05-03-89	51.7	59
OH05E	45	35	10-19-86	38.7	46	12-10-86	01-25-87	39.1	46	11-10-87	38.8	46			
VA05E	55	45	07-30-86	44.8	54	09-09-87	11-19-87	45.0	54	06-28-88	45.0	53			
Raise Speed Limit Sites															
ID03E	20	30	04-15-87	24.2	29	06-01-88	06-02-88	25.3	30	10-03-88	25.0	30			
ID04E	20	30	04-15-87	23.1	29	06-01-88	06-02-88	23.1	29	10-03-88	24.1	30			
MD01E	50	55	08-03-86	54.8	61	09-23-86	01-11-87	55.8	62	02-25-88	56.8	63	06-26-88	56.4	63
MD06E	30	35	08-16-86	40.6	47	10-22-86	12-06-86	40.9	48				07-09-88	40.8	47
TX01E	40	55	09-19-86	47.3	57	10-17-86				03-06-87	43.6	54	12-16-88	45.8	56
VA02E	35	45	07-26-86	39.9	46	10-14-87	12-12-87	42.5	48	06-25-88	43.0	48			

1 mi/h = 1.61 km/h

Shown in figure 32 are the average changes in the before and after 85th percentile speeds for the group of five locations where speed limits were lowered, and the group of six locations where speed limits were raised.

Inspection of figure 32 reveals that for the group of five sites where speed limits were lowered, the average change in 85th percentile speeds was a decrease of less than 1 mi/h (1.6 km/h) for 1 and 2 yr following the speed limit change.

For the group of six sites where speed limits were raised, the average change in 85th percentile speeds was an increase of less than 1 mi/h (1.6 km/h) for 1 and 2 yr following the speed limit change.

The number of sites and the number of repeated measurements are too small to establish trends or permit drawing conclusions concerning the time effects of speed limit changes. The speed measurements taken at 11 selected sites over a 2-yr period after speed limits were altered revealed that small changes (i.e., 2 mi/h (3.2 km/h)) occur in the 24-h 85th percentile speeds of free-flow vehicles at any given site. Similar changes were also found in the mean speeds. For the group of sites where speed limits were lowered, the 85th percentile speeds decreased by less than 1 mi/h (1.6 km/h). At sites where posted speed limits were raised, the 85th percentile speeds increased by 1 mi/h (1.6 km/h) or less.

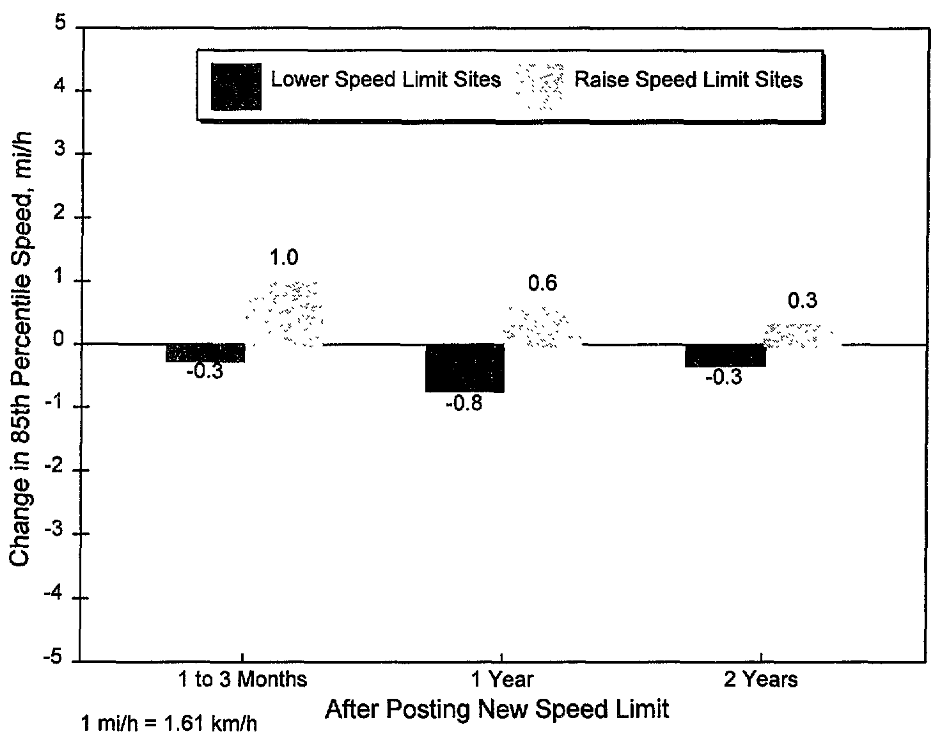


Figure 32. Mean changes in 85th percentile speeds at five sites where speed limits were lowered and at six sites where speed limits were raised.

Indirect Effects on Nearby Roads

Speed, headway, and crash data were collected for five selected highway sections that were contiguous to four experimental sites. The purpose of these measurements was to determine if speed limit changes on the experimental sections had an indirect effect on driver behavior on the contiguous sections. Selection of the contiguous sites was not random, but was dependent on the selection of the experimental sites provided by the participating jurisdictions. Due to cost constraints, the sample of sites studied was limited to five locations.

No speed limit or other alterations to the roadway were made on the contiguous sections during the study period. Posted speed limits on the adjacent experimental sections were lowered at two sites and raised at two other sites. All of the contiguous and experimental sites were two-lane facilities.

The general characteristics of the contiguous sites are shown in table 16. A summary of the before and after 24-h free-flow speed data, as well as the differences in speed characteristics, is given in tables 17 through 19. The percentage of drivers that exceeded the posted speed limits at these sites is shown in table 20. A summary of before and after police-reported crashes on the contiguous sections is shown in table 21. A discussion of the indirect effects at each of the contiguous sites is given below.

The first site listed in table 16, COO1 P, had a posted speed limit of 40 mi/h (64 km/h) and was contiguous to a 1.05-mi (1.69-km) rural experimental section, CO01E, where the speed limit was raised from 30 to 35 mi/h (48 to 56 km/h). The sections were located on the only major highway facility in the area. The general terrain of the area was mountainous, where horizontal and vertical alignment constraints frequently require motorists to reduce speed. Between the before and after data collection periods, there was a 10 percent increase in the 24-h traffic volume on the experimental section. As shown in table 19, there was a 1-mi/h (1.6-km/h) decrease in the percentile speeds on the contiguous section after the speed limit was raised on the experimental section.

Table 16. Contiguous site characteristics.

Parallel Site Number	Jurisdiction	Route	Area	Length, Miles	No. Lanes	Speed Limit mi/h	Intersections Signalized Per Mile	Intersections No Signal Per Mile	Driveways Comm. Per Mile	Driveways Resid. Per Mile
COO1 P	Jefferson County	72	Rural	2.45	2	40	0.00	0.00	0.00	7.76
IN07P	Scott County	31 at Scottsburg	Small Urban	0.37	2	35	0.00	16.22	24.32	27.03
TX06P	City of Justin	FR 156	Rural	0.48	2	35	0.00	18.75	56.25	0.00
WV1 1 P	Kanawha County	62	Rural	0.20	2	45	0.00	5.00	30.00	5.00
WV12P	Kanawha County	62	Rural	1.12	2	45	0.00	11.61	14.29	38.39
5 Sites				4.62 Miles						

1 mi= 1.61 km
1milh = 1.61 km/h
Note: All speed limits are shown in mi/h.

Table 17. Before speed data for the contiguous sites.

Parallel Site Number	Posted Speed Limit	Before Data Collection Date	Mean Speed	Std. Dev. Speeds	Before Volume	Free-Flow Volume	Pct. Free Flow	Percentile Speeds 1	5	IO	15	25	35	50	65	75	85	90	95	99	10-mi/h Pace Lower Limit	10-mi/h Pace Upper Limit	Pct. Pace	Skew. Index
CO01P	40	02/02/87	47.0	4.8	3,275	2,488	76.0	34	40	42	43	45	46	48	49	50	52	53	55	59	43	52	73.8	0.86
IN07P	35	12/17/86	42.3	6.4	8,468	6,634	78.3	24	32	35	37	39	41	43	45	47	49	50	53	57	39	48	62.5	1.00
TX06P	35	03/11/87	34.7	6.9	3,787	3,372	89.0	17	23	26	29	31	33	35	38	40	42	44	46	51	31	40	58.2	1.00
WV11P	45	06/19/86	47.1	8.4	3,720	3,191	85.8	25	33	37	40	43	45	48	51	53	55	58	61	67	43	52	49.3	0.92
WV12P	45	06/19/86	41.0	8.5	8.902	6.888	77.4	22	29	31	32	35	37	41	45	48	50	53	55	61	37	46	39.8	1.08

1 mi/h = 1.61 km/h
Note: All speed limits and vehicle speeds are shown in mi/h.

Table 18. After speed data for the contiguous sites.

Parallel Site Number	Posted Speed Limit	After Data Collection Date	Mean Speed	Std. Dev. Speeds	After Volume	Free-Flow Volume	Pct. Free Flow	Percentile Speeds 1	5	IO	15	25	35	50	65	75	85	90	95	99	10-mi/h Pace Lower Limit	10-mi/h Pace Upper Limit	Pct. Pace	Skew. Index
CO01 P	40	05/16/88	46.5	4.9	3,592	2,642	73.6	33	39	41	42	44	46	47	49	50	51	53	54	58	43	52	74.5	0.92
IN07P	35	08/09/88	42.3	6.9	8,804	7,065	80.2	23	29	33	36	39	41	43	46	47	49	51	53	57	40	49	58.7	0.86
TX06P	35	03/31/88	35.3	6.5	3,853	3,529	91.6	17	25	28	29	32	34	36	38	40	42	44	46	51	32	41	59.5	0.95
WV11P	45	06/21/89	47.1	7.3	5,273	4,056	76.9	27	35	39	41	44	45	48	50	52	55	56	59	64	43	52	56.4	0.95
WV12P	45	06/21/89	41.1	8.4	9.193	7.018	76.3	25	29	31	32	35	38	42	45	48	50	52	55	62	39	48	41.1	1.00

1 mi/h = 1.61 km/h
Note: All speed limits and vehicle speeds are shown in mi/h.

Table 19. Differences in speed characteristics for the contiguous sites.

Parallel Site Number	Posted Speed Limit	Mean Speed	Std. Dev. Speeds	Total Volume	Free-Flow Volume	Pct. Free Flow	Percentile Speeds 1	5	10	15	25	35	50	65	75	85	90	95	99	10-mi/h Pace Lower Limit	Upper Limit	Pct. Pace	Skew. Index
CO01 P	40	-0.5	0.1	317	154	-2.4	-1	-1	-1	-1	-1	0	-1	0	0	-1	0	-1	-1	0	0	0.7	0.06
IN07P	35	0.0	0.5	336	431	1.9	-1	-3	-2	-1	0	0	0	1	0	0	1	0	0	1	1	-3.8	-0.14
TX06P	35	0.6	-0.4	66	157	2.6	0	2	2	0	1	1	1	0	0	0	0	0	0	1	1	1.3	-0.05
WV11P	45	0.0	-1.1	1,553	865	-8.9	2	2	2	1	1	0	0	-1	-1	0	-2	-2	-3	0	0	7.1	0.03
WV12P	45	0.1	-0.1	291	130	-1.1	3	0	0	0	0	1	1	0	0	0	-1	0	1	2	2	1.3	-0.08

1 mi/h = 1.61 km/h
Note: All speed limits and vehicle speeds are shown in mi/h.

Table 20. Percentage of drivers exceeding posted speed limits at the contiguous sites.

Parallel Site Number	Posted Speed Limit	Before: Percent Exceeding Posted Speed Limit 0	5	10	15	20	After: Percent Exceeding Posted Speed Limit 0	5	10	15	20	Differences: Percent Exceeding Posted Speed Limit 0	5	10	15	20
CO01P	40	92.7	68.4	24.7	4.2	0.5	91.8	66.7	21.8	3.2	0.3	-0.9	-1.7	-2.9	-1.0	-0.2
IN07P	35	89.5	67.0	34.0	9.4	1.9	86.7	67.3	36.2	10.4	1.9	-2.0	0.3	2.2	1.0	0.0
TX06P	35	48.5	20.4	6.4	1.2	0.2	54.0	22.2	6.2	1.3	0.1	5.5	1.8	-0.2	0.1	-0.1
WV11P	45	62.2	36.1	14.8	5.3	1.4	63.8	33.2	12.1	3.5	0.7	1.6	-2.9	-2.7	-1.8	-0.7
WV12P	45	33.6	14.5	4.7	1.0	0.2	33.9	14.7	4.6	1.3	0.3	0.3	0.2	-0.1	0.3	0.1

1 mi/h = 1.61 km/h
Note: All speed limits are shown in mi/h

Table 21. Before and after crash data for the contiguous sites.

Parallel Site Number	Posted Limit	Length, Miles	Before Volume	After Volume	Third Before Period B3 Total	B3 Injury	B3 Month	Second Before Period B2 Total	B2 Injury	B2 Month	First Before Period B1 Total	B1 Injury	B1 Month	Total Before B Total	B Injury	B Month	First After Period A1 Total	A1 Injury	A1 Month	Second After Period A2 Total	A2 Injury	A2 Month	Total After A Total	A Injury	A Month
CO01P	40	2.45	3,275	3,592	17	7	12	12	7	12	6	3	12	35	17	36	8	4	12				8	4	12
IN07P	35	0.37	8,468	8,804	6	2	12	3	0	12	9	4	12	18	6	36	4	2	12	4	1	12	8	3	24
TX06P	35	0.48	3,787	3,853	3	0	12	3	2	12	4	2	12	10	4	36	2	1	12				2	1	12
WV11P	45	0.20	3,720	5,273	1	0	12	1	1	12	2	2	12	4	3	36	2	0	12	0	0	12	2	0	24
WV12P	45	1.12	8,902	9,193	11	1	12	10	2	12	17	8	12	38	11	36	11	6	12	14	8	12	25	14	24
5 Sites		4.62			38	10		29	12		38	19		105	41		27	13		18	9		45	22	

1 mi= 1.61 km
1 mi/h = 1.61 km/h
Note: All speed limits are shown in mi/h. Blanks indicate that crash data were not available for the period.

The Indiana site, IN07P, was on a major primary highway located in a small urban area. The speed limit on the section was 35 mi/h (56 km/h). The site was located between two experimental sites, IN06E and IN07E, where the speed limits were lowered from 50 to 45 mi/h (81 to 72 km/h). The 24-h traffic volume increased approximately 4 percent on the experimental sections between the before and after periods. As shown in table 19, there was no change in the mean speed, but there were small reductions in the percentile speeds below the 15th percentile, on the contiguous section, after the posted speed limits were lowered on the experimental sections.

The Texas site, TX06P, passed through a small rural community and was located adjacent to a 0.54-mi (0.87-km) experimental site where the speed limit was raised from 30 to 35 mi/h (48 to 56 km/h). The posted speed limit on TX06P was 35 mi/h (56 km/h). Drivers on the experimental section must turn onto and off of the adjacent section to continue their journey. The experimental and adjacent sections are the only major primary highways in the community. There was a minor change in the 24-h traffic volume on the experimental section during the study period. As shown in table 19, there was a 0.6-mi/h (0.97-km/h) increase in the mean speed, and there were small increases in the percentile speeds below the 50th percentile speed, on the adjacent section, after the posted speed limit was raised on the experimental section.

The two West Virginia contiguous sites, WV1 1 P and WV1 2P, were located in a small city at each end of a 1.14-mi (1.84-km) experimental section where the speed limit was lowered from 45 to 35 mi/h (72 to 56 km/h). The speed limit posted on the contiguous sections was 45 mi/h (72 km/h). The 24-h traffic volume at site WV1 1 P increased by 42 percent; however, the volume at site WV12P only increased by 3 percent during the study period. Based on a review of the area, the volume increase at site WV1 1 P was due to development in the adjacent area, and was not due to drivers attempting to avoid the lower speed limit on the experimental section. There were no other major highways in the area that could be used by drivers to bypass the experimental section. As shown in table 19, changes in the mean speeds at the contiguous sites were minor; however, there was a small increase in the percentile speeds below the 50th percentile and a small decrease in the percentile speeds above the 50th percentile at site WV1 1 P after the speed limit was lowered on the experimental site.

As can be seen by examining table 19, changes in the mean speeds, standard deviation of speeds, and 85th percentile speeds at the contiguous locations were generally less than 1 mi/h (1.6 km/h). As shown in table 20, there were minor changes in the percentage of drivers exceeding the posted speed limits at these sites. The number of before and after police-reported crashes on the contiguous sections, summarized in table 21, is too small to provide meaningful results.

Due to the small sample of sites examined in this study, it is not possible to draw conclusions concerning potential carryover effects of posted speed limit changes on a roadway section to nearby roadways where speed limits were not changed. Drivers on the five contiguous sections examined in this study did not appear to change their behavior, regardless of whether the speed limits were lowered or raised on the experimental sites.

Discussion of Speed Effects

The purpose of this study was to examine the effects of raising and lowering posted speed limits on driver behavior for urban and rural nonlimited access roadways. Although additional enforcement, education, and other engineering measures have been used to effectively manage vehicle speeds, this study only examined the effects of changing the posted speed limit on driver behavior.

Because the participating transportation officials would not permit random selection of sites for speed limit changes, experimental sections were selected from locations where the agencies planned to change posted speed limits as a result of routine traffic and engineering investigations. Comparison sites, where speed limits were not changed, were selected by the research team to control for extraneous factors such as weather conditions. During the time that data were collected, from June 1986 through July 1989, the maximum speed limit on nonlimited access highways was 55 mi/h (89 km/h). At that time, State and local transportation officials typically changed posted speed limits on short roadway segments, i.e., usually less than 2 mi (3.2 km) in length. The average length of sections selected for the study was 1.7 mi (2.7 km). Sixty-three percent of the sites were located in rural areas and small communities with a population of less than 5,000 persons.

Of the 98 sites selected for speed data collection in 22 States, posted speed limits were lowered at 57 sites and raised at 41 other locations. Changes in the posted speed limits ranged from lowering the speed limit by 5, 10, 15, or 20 mi/h (8, 16, 24, or 32 km/h) to raising the speed limit by 5, 10, or 15 mi/h (8, 16, or 24 km/h). During the study, only one change in the posted speed limit was made at each site. Before and after speeds of free-flow vehicles (vehicles with a headway of 4 s or more) were collected for a 24-h period simultaneously at each experimental and comparison site pair.

A review of the before and after speed data at each experimental site revealed that differences in the mean speeds, standard deviation of speeds, and 85th percentile speeds were generally less than 2 mi/h (3.2 km/h). When sites were grouped by amount of speed limit change, the differences in the percentile speeds for each group were less than 1.5 mi/h (2.4 km/h), irrespective of whether the posted speed limit was lowered or raised, or the amount that the limit was changed. While these differences are statistically significant due to the large speed samples collected, the overall change in speeds is small.

At 34 locations, existing speed limits were posted within 5 mi/h (8 km/h) of the 85th percentile speed. Speed limits at these sites were lowered more than 5 mi/h (8 km/h) below the 85th percentile speed. At 21 other locations, existing speed limits were posted more than 5 mi/h (8 km/h) below the 85th percentile speed, and the agencies raised the posted speed limit to within 5 mi/h (8 km/h) of the 85th percentile speed. Comparison of the before and after percentile speeds for both groups of sites revealed that the mean difference in percentile speeds was less than 1 mi/h (1.6 km/h).

Based on the speed data collected at the study sites, speed limits were typically set below the average speed of traffic.

By defining driver compliance as the number or percentage of drivers that travel at or below the posted speed limit, major changes in compliance occurred when speed limits were either raised or lowered. However, as reflected in small changes in vehicle speeds, driver behavior did not change; but the standard for measuring compliance, i.e., posted speed limit, changed.

Because the sites were not randomly selected from the population of nonlimited access highways, the findings apply only to the locations studied, and may apply to other locations where agencies alter speed limits for similar reasons. As noted below, the study findings are similar to the results reported by other researchers who examined driver behavior changes before and after speed limits were changed on nonlimited access highways.

A number of studies have been conducted on nonlimited access highways to examine the effects of changing posted speed limits on driver behavior.[22-33] A summary of the data obtained from published reports is shown in table 22 for urban and rural nonlimited access highways. Table 23 provides a summary of operational studies. It should be noted that studies concerning the effects of posted speed limit changes on limited access high-speed highways are not included in the following discussion, nor are the effects of other speed management techniques, as this study only examined changes in posted speed limits on nonlimited access highways.

Avery conducted before and after studies on 11 arterial streets consisting of segments varying from 1 to 4.5 mi (1.6 to 7.3 km) in length.[22] Speed limits were raised from 30 to 35 mi/h (48 to 56 km/h) on some sections, and from 30 to 40 mi/h (48 to 64 km/h) on other sections. Avery found that the speed changes were small and not related to the amount that the limit was changed.

Ogawa et al. examined the effects of raising the speed limit by 5 mi/h (8 km/h) in two rural towns in Illinois.[24] No significant difference in speeds was found where speed limits were raised; however, a small, but statistically significant increase in speed occurred in one town where the speed limit was lowered.

Roberts found that raising the speed limit from 35 to 40 mi/h (56 to 64 km/h) on a 1.5-mi (2.4-km) four-lane urban street in Columbia, South Carolina, did not significantly change the mean, 85th percentile, or 10-mi/h (16-km/h) pace.[25]

Rowan and Keese conducted before and after studies at 186 locations to determine the effect of speed limit signs on traffic speeds.[29] Speed limits were changed from 60 to 30 mi/h (97 to 48 km/h) and from 30 to 55 mi/h (48 to 89 km/h) in 5-mi/h (8-km/h) increments. They found that speed limit signs had little influence on drivers' speeds; however, they detected a slight decrease in the dispersion of traffic speeds.

Table 22. Summary of research studies on the effects of raising and lowering speed limits.

Location	Author, Date, and Reference	Number of Sections	Speed Limit Before mi/h	Speed Limit After mi/h	Average 85th Percentile Speed, mi/h Before	After Posting Lower Limit	After Posting Higher Limit	Remarks
Urban								
St. Paul, Minnesota	Avery, 1960[22]	7	30	35	35.5		35.8	Compliance increased from 36 to 80 percent.
		4	30	40	39.4		40.8	Compliance increased from 19 to 82 percent.
West Lafayette, Indiana	Elmberg, 1960[23]	1	35	30	38.4	38.5		Percentage of vehicles exceeding the speed limit by 5 mi/h or more increased from 10 to 30 percent.
St. Joseph, Illinois	Ogawa, 1962[24]	1	30	35	30.6*		31.3*	Speed limit revisions based on 85th percentile speeds. The mean speed increase in Ogden is statistically significant.
Ogden, Illinois		1	40	35	32.2*	33.3"		
Fithian, Illinois		1	35	40	34.9*		35.3*	
Columbia, South Carolina	Roberts, 1967[25]	1	35	40	42.5		41.0	Compliance increased from 28 to 76 percent.
10 California Cities	Spitz, 1984[26]	40	NA	NA	39.9		40.3	The 85th percentile speed in the 27 comparison samples where no change in the limit was made increased from 40.1 to 40.8 mi/h.
		10	NA	NA	36.9	38.6		
3 Urban Fringe Areas in Texas	Dudek, 1986[27]	6	55	45	55.9	54.0		Lowering the speed limit had little effect on vehicle speeds and speed variance.

1 mi/h = 1.61 km/h
NA = Not Available
* = Denotes mean speeds, not 85th percentile speeds
[ ] = Numbers in brackets refer to references

Table 22. Summary of research studies on the effects of raising and lowering speed limits (continued).

Location	Author, Date, and Reference	Number of Sections	Speed Limit Before mi/h	Speed Limit After mi/h	Average 85th Percentile Speed, mi/h Before	After Posting Lower Limit	After Posting Higher Limit	Remarks
Rural								
Illinois	Kessler, 1959[28]	30	30	40	38.9		38.4	Driver compliance increased from 39 to 85 percent.
iouston District, Texas	Rowan, 1962[29]	1	60	55	55.5	55.0		Speed limits were established in the after period based on the 85th percentile speeds. A slight increase in the dispersion of speeds was reported after the new limits were established.
		1	60	50	53.7	52.0		
		1	60	45	47.3	46.4		
		1	60	40	41.5	39.9		
		1	60	35	40.2	38.9		
		1	60	30	31.2	33.2		
Paris District, Texas	Rowan 1962[29]	1	60	55	55.2	51.2		
		1	60	50	51.5	50.9		
		1	60	45	47.6	43.9		
		1	60	40	40.4	38.6		
		1	30	55	53.2		50.5	
		1	30	50	52.6		51.3	
		1	30	45	45.4		45.2	
		1	30	40	40.3		42.0	
		1	30	35	36.8		38.4	

mi/h = 1.61 km/h
NA = Not Available
* = Denotes mean speeds, not 85th percentile speeds
[ ] = Numbers in brackets refer to references

Table 23. Summary of operational studies on the effects of raising and lowering speed limits.

Location	Author, Date, and Reference	Number of Sections	Speed Limit Before mi/h	Speed Limit After mi/h	Average 85th Percentile Speed, mi/h: Before	After Posting Lower Limit	After Posting Higher Limit	Remarks
Massachusetts	Oct. 1966[30]	19 Two-lane	30-45	20-35	47.5	48.3		After posting 10-mi/h lower and higher limits than existing zones, no differences in 85th percentile speeds were found.
			30-45	40-55	47.5		48.0	
		6 Dual-lane	50-55	40-45	60.7	60.3		
				60-65	60.7		61.0	
Minnesota	Jan. 1979[31]	12 Two-lane	45	30	NA	43.6		
		4 Four-lane	40	30	42.0	40.3		
Washington	1981-82[32]	3	25	30	34.7		34.3	
		1	50	55	57.0		59.0	
		1	50	35	43.0	42.0		
		3	40	35	45.0	43.7		
Michigan	1982[33]	4	25	35	37.6		36.0	Compliance increased from 10 to 81 percent.
		4	55	50	56.8	54.8		Compliance decreased from 73 to 56 percent.
		4	55	50	57.8	56.0		Compliance decreased from 71 to 46 percent.
		5	45	35	49.2	47.0		Compliance decreased from 56 to 7 percent.

1 mi/h = 1.61 km/h
NA = Not Available
* = Denotes mean speeds, not 85th percentile speeds
[ ] = Numbers in brackets refer to references

Dudek and Ullman conducted before and after studies where speed limits were lowered from 55 to 45 mi/h (89 to 72 km/h) on six urban fringe highway sites in Texas.[27] Roadway section lengths ranged from 2 to 3.9 mi (3.2 to 6.3 km). No significant changes were found in speeds or the speed distributions.

Studies conducted by Avery and Elmberg revealed that there were few changes in the mean, standard deviation, and percentage of vehicles in the pace when speed limits were established on the basis of the 85th percentile speed.[22,23]

While much of the previous speed limit research on nonlimited access highways was limited in scope, several trends are worth noting. First, the magnitude of any change in speed due to a speed limit alteration was small, typically 1 mi/h (1.6 km/h), even in cases with large posted speed limit changes. Secondly, due to the speed limit change and the fact that driver compliance is measured as the number or percentage of motorists driving at or below the posted limit, there was a significant change in compliance.

The findings of the current study, as well as the results of previous research, indicate that changing the posted speed limit did not have a major effect on driver behavior on the urban and rural nonlimited access highway sections that were studied.

EFFECTS ON CRASHES

Prior to collecting before and after speed data for this study, the effects of posted speed limit changes on vehicle speeds for a large sample of jurisdictions were unknown. During the development of the experimental plan, it was assumed that posted speed limits would have an effect on driver speeds, and that the speed changes would be large enough to have an effect on crashes.[10] Accordingly, at that time, a decision was made to collect and analyze crash data.

As the results of the driver behavior analysis indicate, vehicle speed changes at individual study sites, although statistically significant, were small, i.e., generally less than 2 mi/h (3.2 km/h). As there were small differences in vehicle speeds, irrespective of whether posted speed limits were raised or lowered and the amount of the change, there is no reason to suspect that changing posted speed limits at the study sites had an effect on crashes. Thus, any changes in crashes at the study sites may be attributed to other factors beyond the scope of this study, and not to altering the posted speed limits.

As before and after crash data were collected at the experimental and comparison sites, the data were analyzed and the results are reported in this section.

As previously mentioned, the study sites were located in 22 States. In any crash evaluation, the quality of the data is always a major concern.[34] It is well known that crash reporting practices, reporting thresholds, level of detail, and other factors that affect the quality of crash data vary widely among States and jurisdictions. While attempts were made to obtain accurate crash data for the study sites, the overall quality of the data is unknown. Accordingly, the results of this or any other evaluation that uses multi-State data should be interpreted with caution.

Analysis Methodology

As the participating States and jurisdictions would not permit random selection and assignment of sites to experimental and control groups, experimental sites were selected from locations furnished by the jurisdictions where speed limit changes were made as part of a routine traffic and engineering investigation. By necessity, comparison sites were selected by the research team in the field during the review of the experimental sections. Although the team attempted to match comparison sites and experimental sites with similar safety and operational characteristics, i.e., number of

Because a crash at a site is rare compared to other events, such as traffic volume, free-flow vehicle speeds, etc., the minimum sample size requirements for the study were based on estimated crash counts. As sites were furnished by the participating agencies, attempts were made during the site selection process to ensure that the minimum sample size would be obtained. It was clear early in the site selection process that crash counts at the selected sites were less than originally estimated. As a result, additional sites beyond the 100 mi (161 km) originally estimated were selected until all of the available funding for data collection was depleted.

After speed limit changes were made on the experimental sections, police-reported crash data were obtained for each experimental and comparison site. The crash data were received from the participating agencies in a variety of formats, including computerized summaries, hard copies of the reports, and data formatted on computer diskette.

Before and after crash data were collected for 99 experimental sites and their corresponding comparison locations. As speed limits on the experimental sections were posted on different dates, every effort was made to collect as much crash data as possible to increase the sample size. For most locations, the crash data were collected for a 3-yr before period and a 2-yr after period. The final crash data base available for analysis contained 6,307 crashes.

Shown in appendix E are the before and after summaries of the total police-reported crashes and fatal and injury crashes for each experimental and comparison site.

Evaluation Design

The evaluation design selected to estimate the effectiveness of speed limit changes on crashes was the before-and-after design with a comparison group, and a check for comparability.[35] With this design, multiple before and after crash counts are taken at both the experimental and comparison locations. The purpose of the multiple measurements is to determine if the comparison locations are suitable comparisons for the experimental sites. The purpose of the comparison group is to account for changes in safety (such as weather conditions, driver characteristics, etc.) between the before and after periods, The primary benefit of this design is that the comparison group controls for extraneous factors, and as multiple measurements are made over a number of years, some relief from regression-to-the-mean bias is possible.

Numerous statistical methods have been used for analyzing categorical crash data. Each method contains strengths and weaknesses. For example, the simple before-and-after design may be biased due to nonrandom errors introduced by unaccounted for factors that unevenly affect crashes in the before or after period. On the other hand, the use of a comparison group with a small number of crashes can also bias the results. Due to the strengths and weaknesses of various analysis methods, four different techniques were used to estimate the safety effects of the speed limit changes.

The first method, reported by Griffin, uses multiple before and after analyses with paired comparison ratios to estimate the overall safety effects at multiple treatment locations.[36,37] The second method is the classical cross-product ratio or odds ratio that estimates safety effects based only on the total crash counts at the sites. Application of this method is also discussed by Griffin.[35]

Because regression-to-the-mean is an important factor that can often lead to erroneous conclusions in crash analyses, the third analysis method employed the use of a new empirical Bayes method, EBEST (Empirical Bayes Estimation of Safety and Transportation), which adjusts for regression-to-the-mean bias and provides a more realistic estimate of the safety effects.[38] The EBEST procedure requires a reference group and measurement of site exposure. Because the reference group available for use in this study was smaller than required for appropriate application of the method, the procedure was used primarily to approximate the amount of regression-to-the-mean bias in the dataset.

The fourth analysis method is the before-and-after design that uses the weighted average logit to produce an overall estimate of safety effects at multiple treatment locations.[39] This method does not use comparison sites to control for extraneous factors. The results obtained with the before-and-after design may contain nonrandom errors such as changes in traffic volumes, weather conditions, crash reporting thresholds, and other factors. Thus, the safety estimates produced by this method may be biased and invalid.

The before-and-after design with a comparison group and a check for comparability can be used to estimate the effects of a treatment on crashes at a single site or for a group of sites if the number of reported crashes is sufficiently large. In this study, the design was used to estimate safety effects for groups of sites. The design was not used to estimate the effect of posted speed limit changes on crashes at each individual experimental site due to the small number of crash counts at the experimental and comparison sites. In addition, the comparison group must have a sufficient number of crashes, otherwise, it is better not to use it.[40]

The comparison group was not used to estimate the safety effects when the comparability tests indicated that the crash histories either during the before period or during the after period at the experimental and comparison sites were not comparable. When the groups were not comparable, the before-and-after design, using the weighted average logit, was employed.[39]

The null hypothesis tested was that the observed crashes after treatment, i.e., installation of the new speed limit signs, were equal to the expected crashes after treatment. All statistical analyses were conducted at the 0.05 significance level (a). Rejection of the null hypothesis required a probability or p-value <0.05.

For each of the analysis methods, the expected crashes after treatment explicitly considered unequal before and after reporting periods and changes in traffic volumes at the sites.

Procedure

The analysis procedure included the following steps:

(1) Conduct a check for comparability.

(2) Estimate the treatment effects using multiple before and after analyses with paired comparison ratios. The comparison ratios adjust the expected number of crashes for unequal time periods and changes in traffic volumes.

(3) Estimate the treatment effects using the classical cross-product ratio or odds ratio based on the total number of crashes in the evaluation group.

(4) Use the empirical Bayes method to examine the amount of regression-to-the-mean bias present in the sample.

(5) Estimate the safety effects using the before-and-after design that employs the weighted average logit.

Estimates of the effects of speed limit changes on total crashes were made for the following groups:

- The 58 experimental sites where posted speed limits were lowered using 49 corresponding comparison sites. In addition, the sites were further analyzed by level of posted speed limit change, i.e., reduced by 5, 10, or 15 and 20 mi/h (8, 16, or 24 and 32 km/h).

- The 41 experimental sites where posted speed limits were raised using 34 corresponding comparison sites. These sites were further subdivided into two groups, i.e., raised 5 mi/h (8 km/h) and raised 10 and 15 mi/h (16 and 24 km/h).

- The 21 sites where speed limits were posted within 5 mi/h (8 km/h) of the 85th percentile speed and the 34 sites where the speed limits were posted more than 5 mi/h (8 km/h) below the 85th percentile speed.

Estimates of the effects of speed limit changes on fatal and injury crashes were also made for the lowered and raised speed limit groups. Due to sample size limitations of these data, no analyses were conducted for the amount of speed limit change groups.

Although it is possible to subdivide the sites into other groups, this was not done as further subdivisions produced too small a sample size for analysis.

Details of the analysis procedure, along with an example of the paired comparison ratios method, are provided in appendix F.

Results

As previously mentioned, the statistical analyses were conducted for sites where speed limits were lowered and sites where speed limits were raised. A summary of the results by analysis method is provided in table 24. illustrated graphically in figure 33 are the 95 percent confidence limits, which are very large for both lowered and raised posted speed limit conditions.

As shown in table 24, the results of the statistical tests indicated that there is not sufficient evidence in this dataset to reject the hypothesis that total crashes or fatal and injury crashes changed when posted speed limits were either raised or lowered.

The EBEST analysis indicated that the average shrinkage in the dataset where speed limits were lowered was 0.15. The average shrinkage in the dataset where speed limits were raised was 0.10. Average shrinkage factors range from 0 (no regression-to-the-mean bias) to 1 .0, indicating substantial bias. The shrinkage factors mentioned above provide an indication that regression-to-the-mean may not be a major factor with this dataset.

The paired comparison ratios method indicated that there was a statistically significant increase in crashes at the 14 sites where speed limits were lowered by 5 mi/h (8 km/h). This result must be viewed with caution due to the small number of crashes in the sample.

The before-and-after method indicated that there was a significant decrease in crashes at the 41 sites where speed limits were raised. This result is contrary to the results of the other methods and may be due to the previously cited limitations of the before-and-after method.

Results at 85th Percentile Sites

Crash data were analyzed for the 34 experimental sites where posted speed limits were initially within 5 mi/h (8 km/h) of the 85th percentile speeds and posted speed limits were lowered at these sites more than 5 mi/h (8 km/h) below the 85th percentile speeds. An analysis was also conducted for the 21 sites where speed limits were initially set more than 5 mi/h (8 km/h) below the 85th percentile speeds, and the posted speed limits were raised to within 5 mi/h (8 km/h) of the 85th percentile speeds.

As shown in table 25, there is not sufficient evidence in this dataset to reject the hypothesis that crash experience changed when posted speed limits were either raised to within 5 mi/h (8 km/h) of the 85th percentile speeds or lowered more than 5 mi/h (8 km/h) below the 85th percentile speeds. The 95 percent confidence limits for these estimates, which are large, are shown in figure 34.

Table 24. Summary of statistical tests.

Group	Crash* Sample Size Before	Crash* Sample Size After	Comparability G-Value 3 df	Comparability G-Value prob.	Analysis Method	Percent Change in Crashes	Z-Value	prob.	95 Percent Confidence Limits Lower	95 Percent Confidence Limits Upper	X^2 Homogeneity	Degrees of Freedom	prob.
Lower Speed Limit Sites													
58 Experimental	1,247	776	1.85	0.61	Paired Comp.	6.86	0.74	0.46	-10.42	27.47	48.36	57	0.78
49 Comparison	635	405			Odds Ratio	-2.43	-0.31	0.76	-16.32	13.76			
					EBEST	-1.45	-0.33	0.74	Reference group too small to provide reliable results.				
					Before-After	0.80	0.17	0.87	-8.09	10.55	56.05	57	0.51
Fatal and Injury Crashes													
58 Experimental	456	271	2.94	0.37	Paired Comp.	5.20	0.35	0.73	-20.59	39.38	38.37	57	0.97
49 Comparison	263	162			Before-After	1.50	0.19	0.85	-13.16	18.64	37.16	57	0.98
Lower Limit by 5 mi/h													
14 Experimental	291	214	0.69	0.87	Paired Comp.	44.44	2.29	0.02	5.38	97.98	12.23	13	0.51
12 Comparison	198	131			Before-After	17.29	1.71	0.09	-2.31	40.81	15.22	13	0.30
Lower Limit by 10 mi/h													
34 Experimental	735	441	3.56	0.32	Paired Comp.	-7.13	-0.62	0.54	-26.39	17.16	22.43	33	0.92
31 Comparison	351	227			Before-After	-3.91	-0.65	0.52	-14.87	8.45	30.99	33	0.57
Lower Limit by 15 or 20 mi/h													
10 Experimental	221	121	5.38	0.15	Paired Comp.	-4.72	-0.20	0.84	-41.34	54.76	8.64	9	0.48
9 Comparison	105	59			Before-After	-5.62	-0.50	0.62	-24.86	18.54	6.29	9	0.71
Raise Speed Limit Sites													
41 Experimental	1,169	683	7.33	0.07	Paired Comp.	-11.28	-1.37	0.18	-25.24	5.30	34.93	40	0.70
34 Comparison	861	534			Odds Ratio	-5.80	-0.82	0.41	-18.38	8.73			
					EBEST	-5.91	-1.27	0.20	Reference group too small to provide reliable results.				
					Before-After	-9.98	-2.10	0.04	-18.38	-0.72	42.46	40	0.37
Fatal and Injury Crashes													
41 Experimental	459	282	5.52	0.15	Paired Comp.	-6.78	-0.52	0.60	-28.28	21.18	28.92	40	0.90
34 Comparison	350	226			Before-After	-3.21	-0.42	0.67	-16.93	12.77	31.24	40	0.83
Raise Limit by 5 mi/h													
26 Experimental	816	537	18.30	>0.001	Before-After	-8.28	-1.51	0.14	-18.02	2.63	32.68	25	0.15
23 Comparison	599	431											
Raise Limit by 10 or 15 mi/h													
15 Experimental	353	146	12.61	0.008	Before-After	-15.21	-1.61	0.11	-30.61	3.61	9.33	14	0.80
12 Comparison	274	107											

1 mi/h = 1.61 km/h

* Crash counts are based on a 3-yr before and a 2-yr after period at most sites. See appendix E for crash counts at each site.

Table 25. Summary of crash results at 85th percentile sites.

Group	Crash* Sample Size Before	Crash* Sample Size After	Comparability G-Value 3 df	Comparability prob.	Analysis Method	Percent Change in Crashes	Z-Value	prob.	95 Percent Confidence Limits Lower	95 Percent Confidence Limits Upper	X^2 Homogeneity	Degrees of Freedom	prob.
Sites where speed limits were within 5 mi/h of the 85th percentile steeds and speed limits were lowered more than 5 mi/h below the 85th Percentile speeds													
34 Experimental	854	501	4.40	0.22	Paired Comp.	13.90	1.24	0.22	-7.26	39.90	34.75	33	0.39
30 Comparison	478	291			Before-After	0.25	0.04	>0.90	-10.46	12.24	33.91	33	0.43
Sites where speed limits were more than 5 mi/h below the 85th oercentile speeds and speed limits were raised to within 5 mi/h of the 85th oercentile speeds													
21 Experimental	693	407	29.38	>0.001	Before-After	-8.32	-1.34	0.18	-19.25	4.09	19.75	20	0.48
17 Comparison	409	202											

1 mi/h = 1.61 km/h

* Crash counts are based on a 3-yr before and a 2-yr after period at most sites.
See appendix E for crash counts at each site.

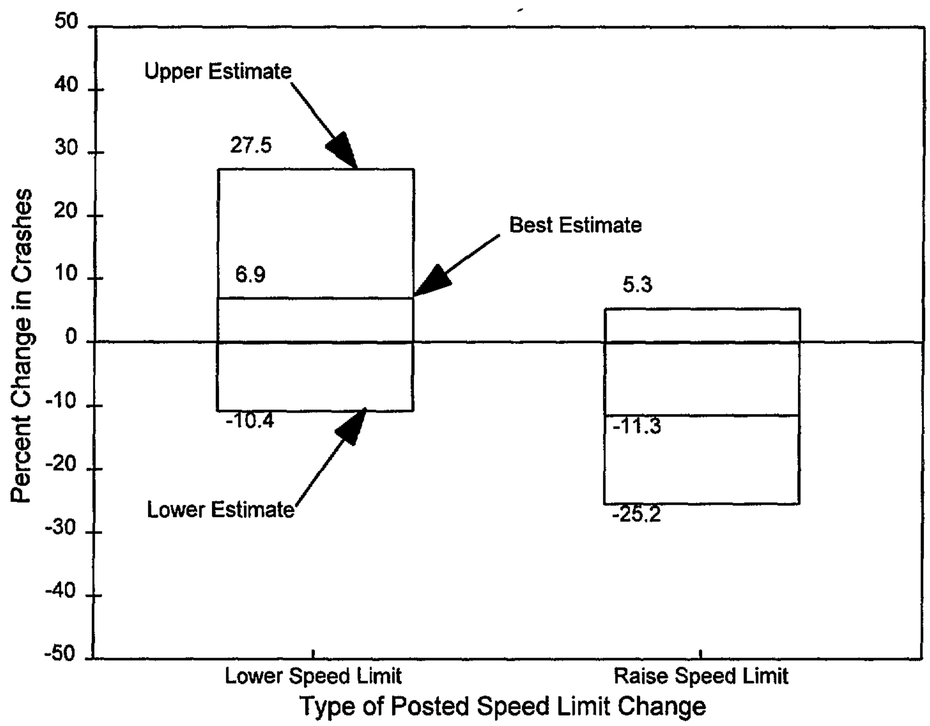


Figure 33. Summary of crash effects at sites where posted speed limits were altered.

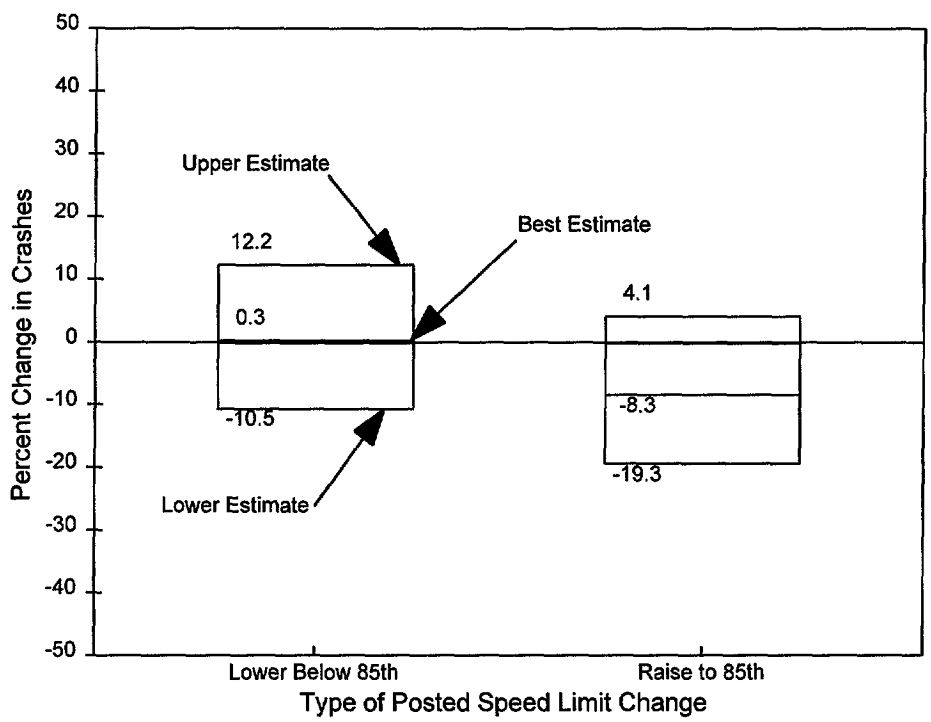


Figure 34. Summary of crash effects at sites where speed limits were lowered below or raised to the 85th percentile speeds.

Multiple-Vehicle vs. Single-Vehicle Crashes

Before-and-after crash data collected at the study sites provided information on crash severity, persons killed and injured, collision type, number of vehicles, lighting conditions, roadway surface conditions, intersection-relatedness, and estimated speeds of the vehicles involved in the crashes. Information on contributing circumstances was not available for all jurisdictions. While a breakdown of the crashes by each of these variables is possible, the resulting number of crashes is too small to provide meaningful results.

In order to provide an indication of the sample sizes for each speed limit change group, the crash data were summarized for multiple-vehicle and single-vehicle crashes for equal before and after time periods. The results are shown in table 26. If lowering the speed limit resulted in additional vehicle queues, one might expect an increase in multiple-vehicle crashes. On the other hand, if speed limits were raised, it is plausible that there could be an increase in single-vehicle crashes, assuming that all other factors remained the same.

As shown in table 26, there was a small percent increase in multiple-vehicle crashes for all speed limit groups. As traffic volumes increased by 4 to 12 percent during the study period for the group of sites, this result is most likely due to volume increases at the sites, as opposed to the posted speed limit change. In fact, the limited amount of short headway data collected during the study indicated that the proportion of vehicles traveling at short headways after the new speed limits were posted did not change at locations where traffic volumes did not change.

Table 26. Multiple-vehicle and single-vehicle crashes.

Speed Limit Change, mi/h	Multiple-Vehicle					Single-Vehicle				
	3-yr Before		2-yr After		Diff.	3-yr Before		2-yr After		Diff.
	No.	Pct.	No.	Pct.	Pct.	No.	Pct.	No.	Pct.	Pct.
-15 & -20	149	67.42	74	72.55	5.13	72	32.58	28	27.45	-5.13
-10	503	68.44	270	74.38	5.94	232	31.56	93	25.62	-5.94
- 5	205	74.01	177	83.10	9.09	72	25.99	36	16.90	-9.09
+ 5	548	69.28	393	74.86	5.58	243	30.72	132	25.14	-5.58
+10 & +15	275	77.90	115	79.31	1.41	78	22.10	30	20.69	-1.41

1 mi/h = 1.61 km/h

Crash-Speed Relationships

In an effort to examine if changes in the speed distributions produced corresponding changes in crashes at the study sites, scatter plots of selected variables were developed. No attempt was made to develop a mathematical model, as the primary interest was to examine before-and-after differences in the variables.

Selected parameters of the speed distributions were plotted against changes in crashes at the experimental sites. For example, the changes in crashes vs. the changes in 85th percentile speeds are shown in figure 35 for sites where speed limits were lowered. The data for sites where speed limits were raised are shown in figure 36. The changes in crashes vs. the changes in mean speeds are shown in figures 37 and 38 for the lowered and raised sites, respectively. The changes in crashes vs. the changes in coefficients of variation (the standard deviation divided by the mean) of speeds are shown in figures 39 and 40 for the lowered and raised sites, respectively.

As can be seen by examining figures 35 through 40, the scatter plots do not provide an indication of any relationship between changes in crashes and changes in the three speed parameters examined. It is important to note, however, that the changes in the speed distributions are quite small, perhaps too small to have an effect on crashes.

Changes in crashes with changes in other speed variables, including the 50th percentile speed, the upper limit of the pace, and the skewness index, were plotted. These plots also did not reveal any trends or relationships.

A scatter plot was also developed to determine if a relationship exists between the ratio of after-to-before 85th percentile speeds and the ratio of after-to-before crashes. For example, if the after-to-before speed ratio is greater than 1 .O, there has been an increase in the 85th percentile speed. One might expect that an increase in speed could increase the crash ratio. Similarly, when the speed ratio is less than 1 .O, one might expect a decrease in the crash ratio. Shown in figures 41 and 42 are plots of the crash-speed ratios for the lowered and raised speed limit sites, respectively. These plots also do not show a relationship between the crash-speed ratios.

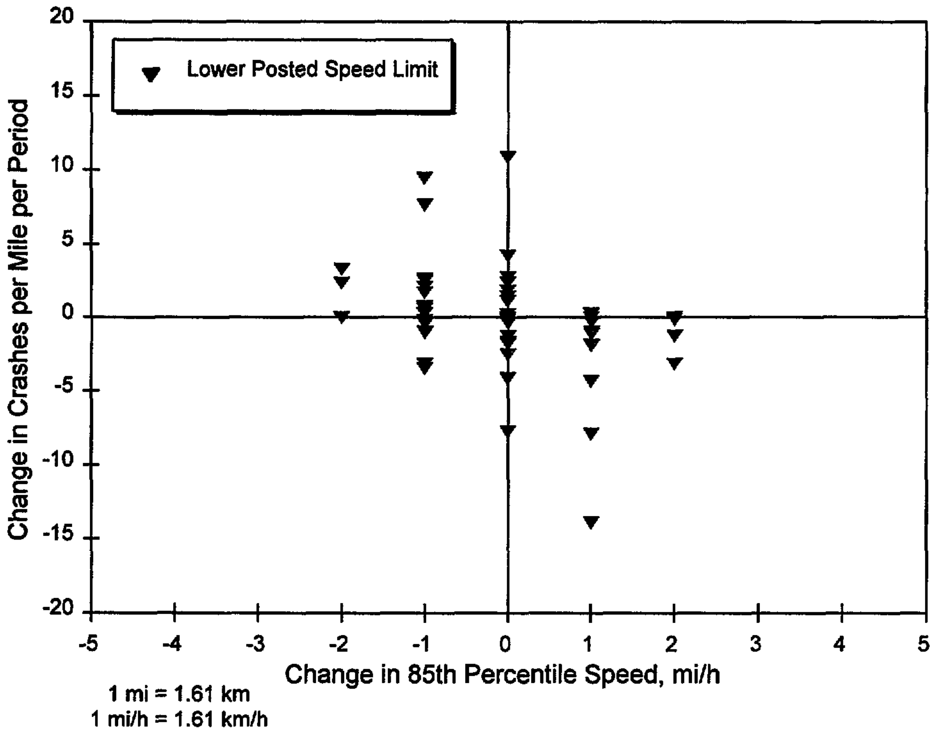


Figure 35. Before and after changes in crashes vs. changes in the 85th percentile speeds at sites where speed limits were lowered.

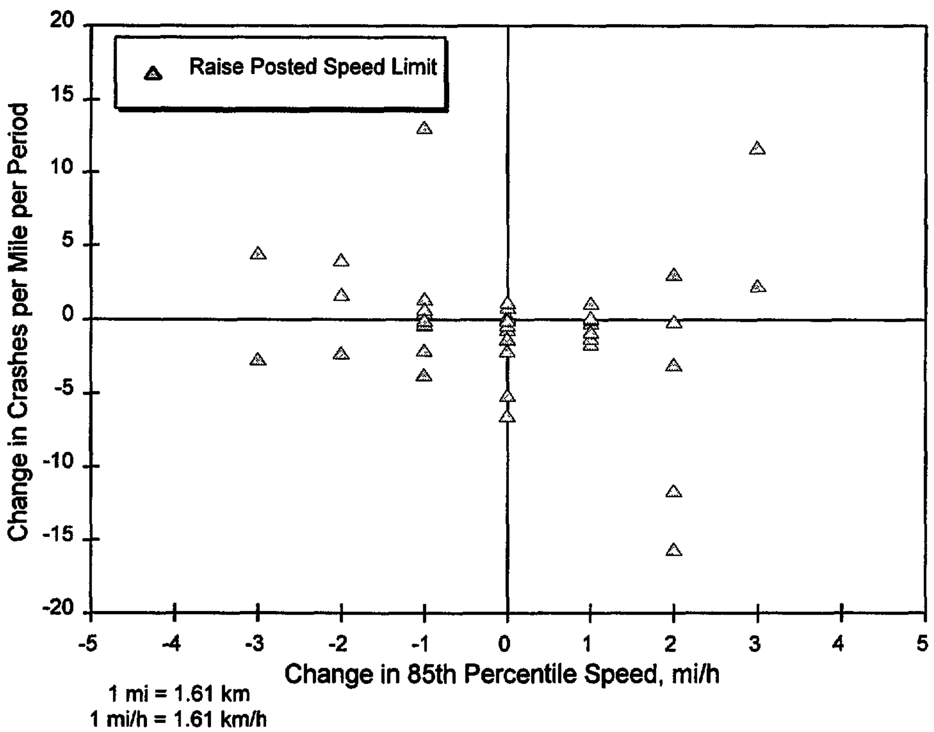
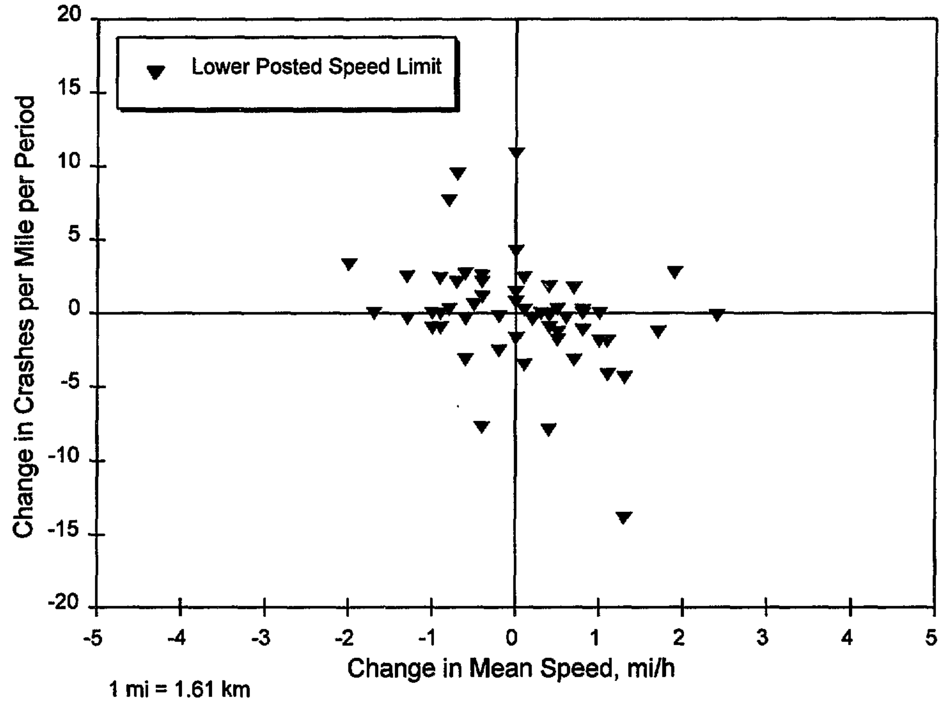
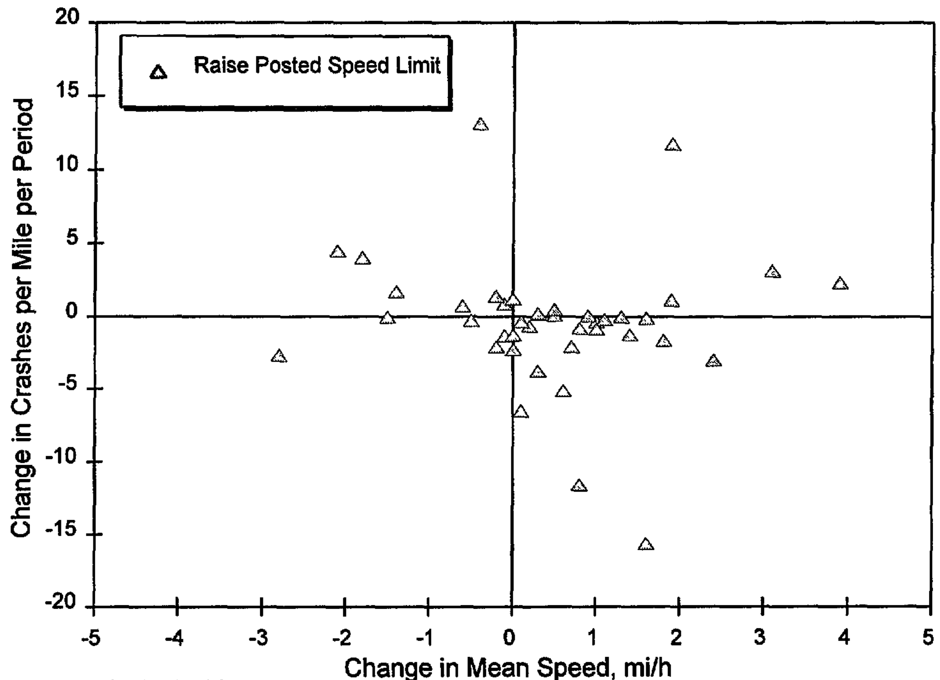


Figure 36. Before and after changes in crashes vs. changes in the 85th percentile speeds at sites where speed limits were raised.



1 mi = 1.61 km
1 mi/h = 1.61 km/h

Figure 37. Before and after changes in crashes vs. changes in the mean speeds at sites where speed limits were lowered.



1 mi = 1.61 km
1 mi/h = 1.61 km/h

Figure 38. Before and after changes in crashes vs. changes in the mean speeds at sites where speed limits were raised.

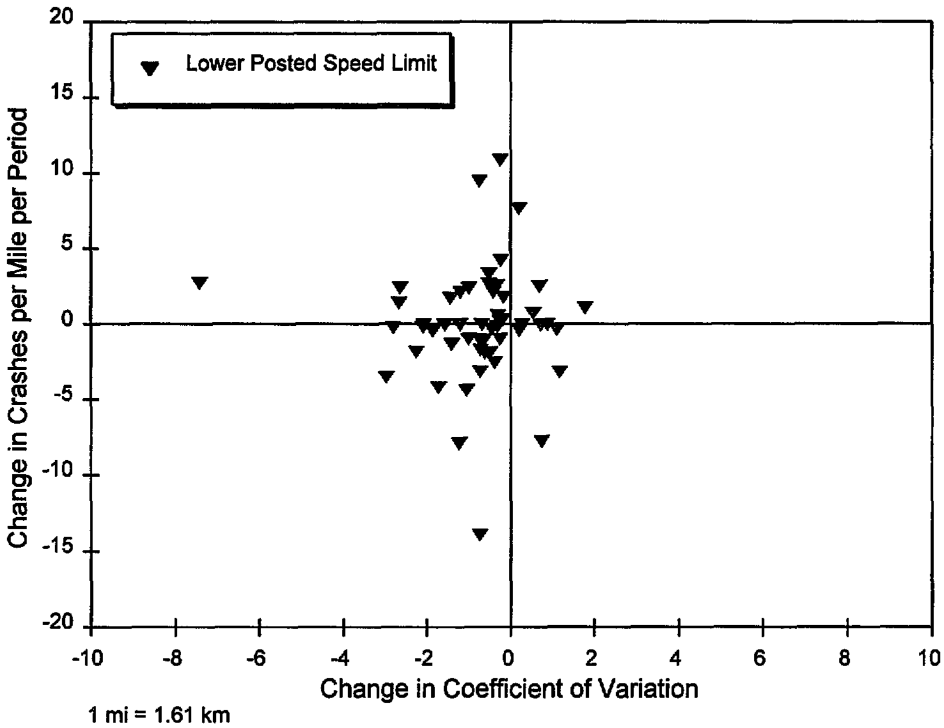


Figure 39. Before and after changes in crashes vs. changes in the coefficients of variation of speeds at sites where speed limits were lowered.

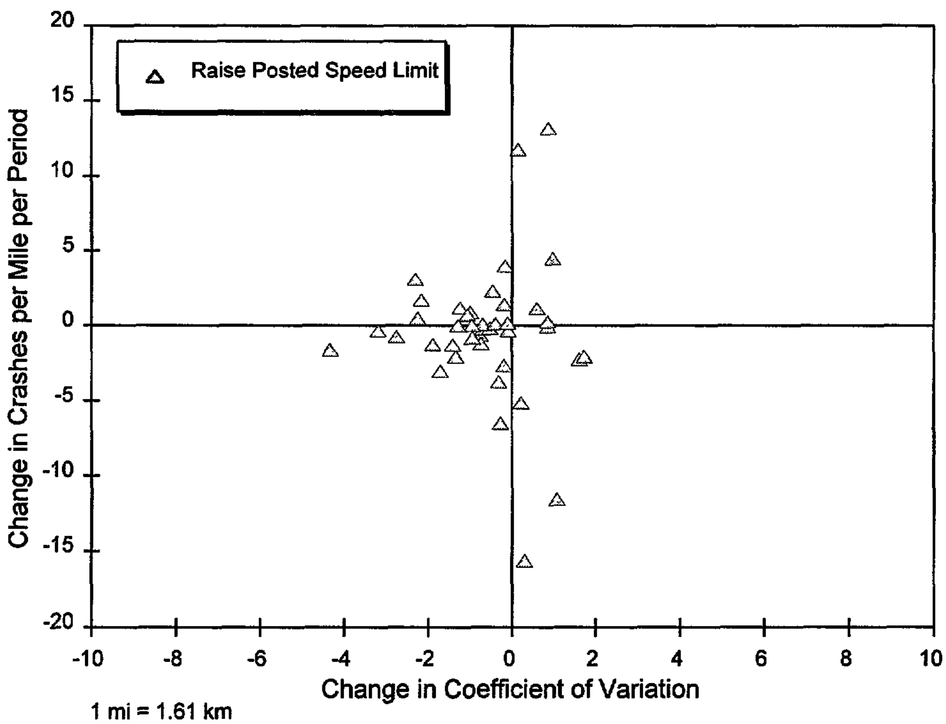
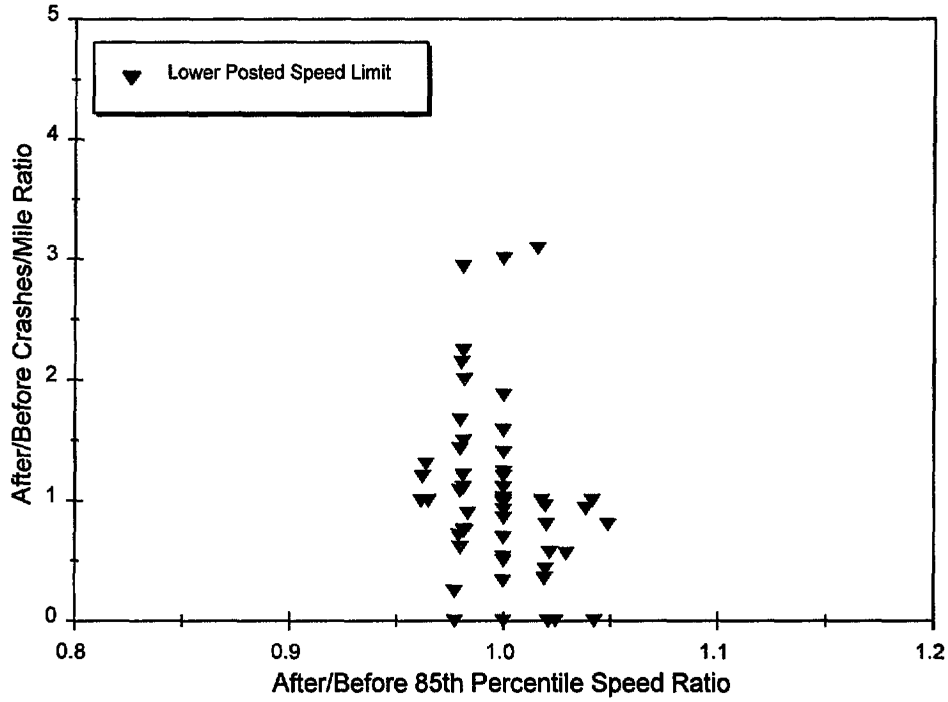
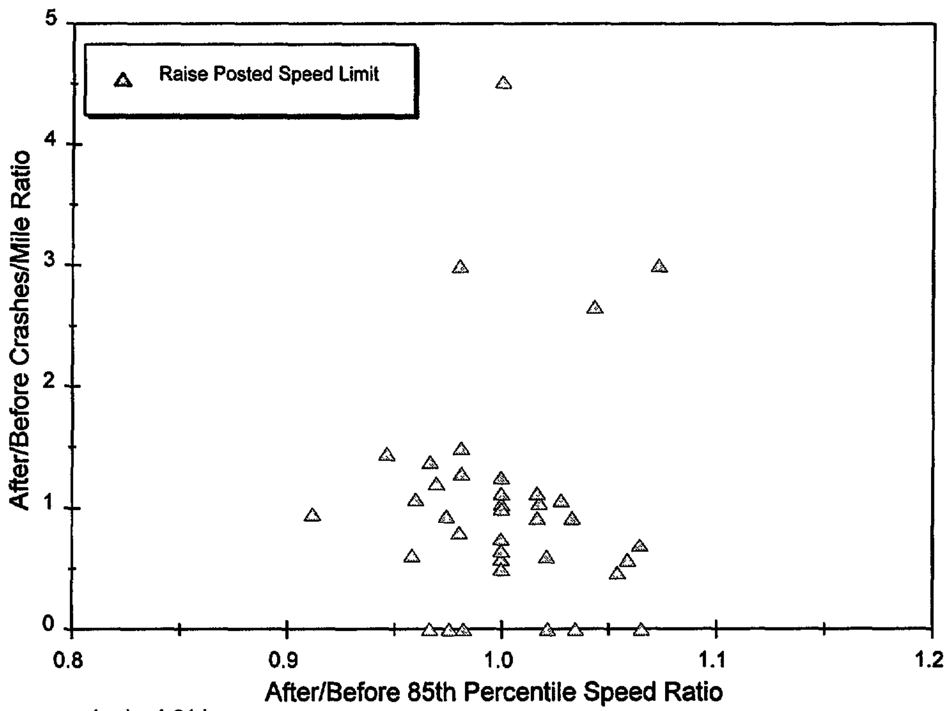


Figure 40. Before and after changes in crashes vs. changes in the coefficients of variation of speeds at sites where speed limits were raised.



1 mi = 1.61 km

Figure 41. Ratio of the change in crashes vs. ratio of the change in 85th percentile speeds where speed limits were lowered.



1 mi = 1.61 km

Figure 42. Ratio of the change in crashes vs. ratio of the change in 85th percentile speeds where speed limits were raised.

Discussion of Crash Effects

Before and after crash data were collected at the study locations because it was assumed that posted speed limits could have an effect on driver speeds, and that the speed changes would be large enough to have an effect on crashes. As the results of the before and after speed analyses indicate, vehicle speed changes at the study sites were small. Accordingly, it is not logical to assume that changing the posted speed limits at the study sites had an effect on crashes.

As before and after crash data were collected at the study sites, the data were analyzed using four crash evaluation analysis methods. Before and after crash data were analyzed for 99 experimental sites and their corresponding comparison locations.

The results of the statistical tests indicate that there is not sufficient evidence to reject the hypothesis that total crashes or fatal and injury crashes changed when posted speed limits were either raised or lowered.

Crash data were also analyzed for 34 experimental sites where posted speed limits were initially set within 5 mi/h (8 km/h) of the 85th percentile speeds and posted limits at these sites were lowered more than 5 mi/h (8 km/h) below the 85th percentile speeds. An analysis was also conducted for the 21 sites where speed limits were initially set more than 5 mi/h (8 km/h) below the 85th percentile speeds and the limits at these sites were raised to within 5 mi/h (8 km/h) of the 85th percentile speeds. The results of these analyses indicate that there is not sufficient evidence to reject the hypothesis that crash experience changed when posted speed limits were either lowered more than 5 mi/h (8 km/h) below the 85th percentile speeds or raised to within 5 mi/h (8 km/h) of the 85th percentile speeds.

Because random selection and assignment of roadway sections to experimental groups for posted speed limit changes and to control groups were not possible, these findings apply only to the study locations and cannot be generalized.

Although many transportation engineers and the public consider posted speed limits to be associated with safety, very few investigators have studied the effect of changing speed limits on crashes on nonlimited access highways. Most of the recent studies have dealt with the effects of 55- and 65-mi/h (89- and 105-km/h) speed limits on crashes on high-speed limited access highways. As the scope of this study only included nonlimited access facilities, the following discussion only pertains to studies on nonlimited access highways.

Kessler found that when speed limits were raised at 30 locations in Illinois, the 85th percentile speeds did not change; however, the number of crashes decreased from 62 to 40.[28]

Wenger examined crash experiences at 25 locations in St. Paul, Minnesota, and found that raising speed limits from 30 to 35 or 40 mi/h (48 to 56 or 64 km/h) adversely affected crashes.[41]

Dudek and Ullman examined the impacts of posting speed limits below the 85th percentile speeds at six locations in Texas and found no conclusive effect on either travel speeds or crashes.[27]

McCoy et al. collected crash, speed, and other data at 38 nonlimited access sites in Nebraska.[42] The sections examined ranged from 0.2 to 1.2 mi (0.3 to 1.9 km) in length, and average daily traffic volumes ranged from 500 to 20,000 vehicles. The results of their analyses indicated that sites with reasonable speed limits set by the Nebraska Department of Roads' method of speed zoning were safer than zones with posted speed limits that were set 5 or 10 mi/h (8 or 16 km/h) below the reasonable limits.

One problem with the previous research, including the current study, is the small number of crashes used to estimate the safety effects.

The study with the largest crash sample size conducted to date was completed by Parker in Michigan.[21] The study included experimental sites where posted speed limits were changed, and corresponding comparison sites where no changes were made. Before and after crash data were collected for 68 nonlimited access highway sections and 86 comparison sections. At the experimental sites, 11,120 crashes were available for analysis. At the 86 comparison sites, 26,617 crashes were analyzed.

Analysis of the data indicated that there was not sufficient evidence to reject the hypothesis that crash experience changed when posted speed limits were either raised or lowered. The same finding was reported for sites where the speed limit was set at the 85th percentile speed and at sites where the speed limit was posted more than 5 mi/h (8 km/h) below the 85th percentile speed. Although the Michigan crash data base was much larger than the crash data base used in the current study, the results were the same.

Based on the best information available to date, there is no evidence to suggest that lowering or raising posted speed limits on nonlimited access roadways has an effect on crashes. Reducing the posted speed limit without utilizing other enforcement, educational, and engineering measures does not appear to be an effective safety treatment.

SUMMARY, FINDINGS, AND CONCLUSIONS

SUMMARY

This research was conducted to examine the effects of raising and lowering posted speed limits on driver behavior for urban and rural nonlimited access roadways. The scope of the study was limited to examining changes in driver behavior when the only change was an alteration in the posted speed limit.

Due to legislative requirements, tort liability issues, and public confidence concerns, the participating States and jurisdictions would not permit the research team to randomly select and assign roadway sections for speed limit changes. Because the original study design could not be implemented, experimental sections were selected from locations where transportation agencies planned to change posted speed limits as a result of routine traffic and engineering investigations. Based on safety and operational characteristics, comparison sites were selected by the research team during a field review of the experimental locations.

The study was conducted from October 1985 to September 1992, when the maximum speed limit was 55 mi/h (89 km/h) on nonlimited access highways. During this period, the States and localities lowered and raised posted speed limits on short roadway segments, typically less than 2 mi (3.2 km) in length. The general types of sites included in the study were:

1. A roadway section in a small rural town or community where the speed limit on the adjoining roadway sections was 55 mi/h (89 km/h). The length of these sections varied between 0.5 and 1 mi (0.8 and 1.6 km).

2. A roadway section in an urban. suburban. or rural area where public or political requests or increases or decreases in the adjacent land use and corresponding traffic volumes dictated the need for a change in the speed limit. These sections were typically 1 mi (1.6 km) in length.

3. A two- or four-lane nonlimited access roadway section in a rural area where the speed limit was raised to 55 mi/h (89 km/h). These sections were between 2 and 12 mi (3.2 and 19.3 km) in length.

Posted speed limits were changed for the following reasons:

- As a result of a request from the public, political leaders, or enforcement officials.
- To ensure that speed limits were appropriate for roadway and traffic conditions.
- As a result of a high incidence of traffic crashes.
- To comply with local laws or ordinances.
- In response to changing traffic volume and land-use patterns.

The study included the collection of driver behavior and crash data in 22 States. The data were collected at 100 sites on nonlimited access highways, consisting of 172 mi (277 km) where speed limits were either lowered or raised, and at 83 comparison sites, consisting of 132 mi (213 km), where no changes in the posted speed limits were made. Sixty-three percent of the sites selected were in rural areas and small communities with a population of less than 5,000 persons. Ninety-four percent of the sections were two-lane highways. Traffic volumes on the sections ranged from 300 to 17,000 vehicles/day.

Of the 100 study sites, posted speed limits were lowered at 59 sites and raised at 41 other locations. Changes in the posted speed limits ranged from lowering the speed limit by 5, IO, 15, or 20 mi/h (8, 16, 24, or 32 km/h) to raising the speed limit by 5, 10, or 15 mi/h (8, 16, or 24 km/h). Only one change in the posted speed limit was made at each site during the study.

Speed limits on the experimental sections were changed between July 1986 and May 1989. The before speed data were collected between June 1986 and June 1988. The after speed data were collected between August 1987 and July 1989. Collection of the before data ranged from several days to 2 years prior to the speed limit change. Collection of the after data ranged from several days to as much as 2 years following the speed limit change.

The examination of driver behavior data, collected at 98 experimental sections, included the speed distribution (percentile speeds), mean speeds, speed variance, percentage of drivers exceeding the posted speed limit, and close following behavior. Before and after speeds of free-flow vehicles (vehicles with a headway of 4 s or more) were collected for a 24-h period simultaneously at each experimental and comparison site pair.

The crash data collected included police-reported crashes, crashes involving injury or death, and multiple-vehicle and single-vehicle crashes. Before and after crash data were collected at 99 experimental sections and their corresponding comparison sections. For most sections, crash data were available for a 3-yr period before the speed limit was changed and for a 2-yr after period. A total of 6,307 police-reported crashes were used in the analysis.

Analyses were conducted to examine before-and-after differences in driver behavior at each site. The sites were divided into lowered posted speed limit and raised posted speed limit groups. The sites were further subdivided into groups based on the amount of posted speed limit change. Group means and other statistics were calculated for each of the speed variables collected.

Four evaluation methods were used to analyze the crash data. The methods included multiple before and after analyses with paired comparison ratios, the classical cross-product ratio, the new empirical Bayes method, and the before-and-after design using a weighted average logit to produce an overall estimate of safety effects.

FINDINGS

Sites for this study were selected from locations where the participating agencies planned to make speed limit changes. Nonrandom selection of sites can produce biased results and limits the findings and conclusions to the locations studied. The findings may apply to similar sites where the speed limits are changed for similar reasons. Generalizations to other roadways are not appropriate.

This study, conducted to examine the effects of lowering and raising posted speed limits on nonlimited access rural and urban highways, produced the following findings:

- A review of the before and after speed data at each site revealed that differences in mean speeds, standard deviations of speeds, 85th percentile speeds, and other percentile speeds were generally less than 2 mi/h (3.2 km/h) and were not related to the amount the posted speed limit was changed.

- When sites were grouped by amount of speed limit change, the differences in percentile speeds for each group were less than 1.5 mi/h (2.4 km/h), irrespective of whether the speed limit was lowered or raised or the amount that the limit was changed. As shown in figure 43, the average change in percentile speeds at sites where speed limits were lowered and at sites where speed limits were raised was less than 1 mi/h (1.6 km/h).

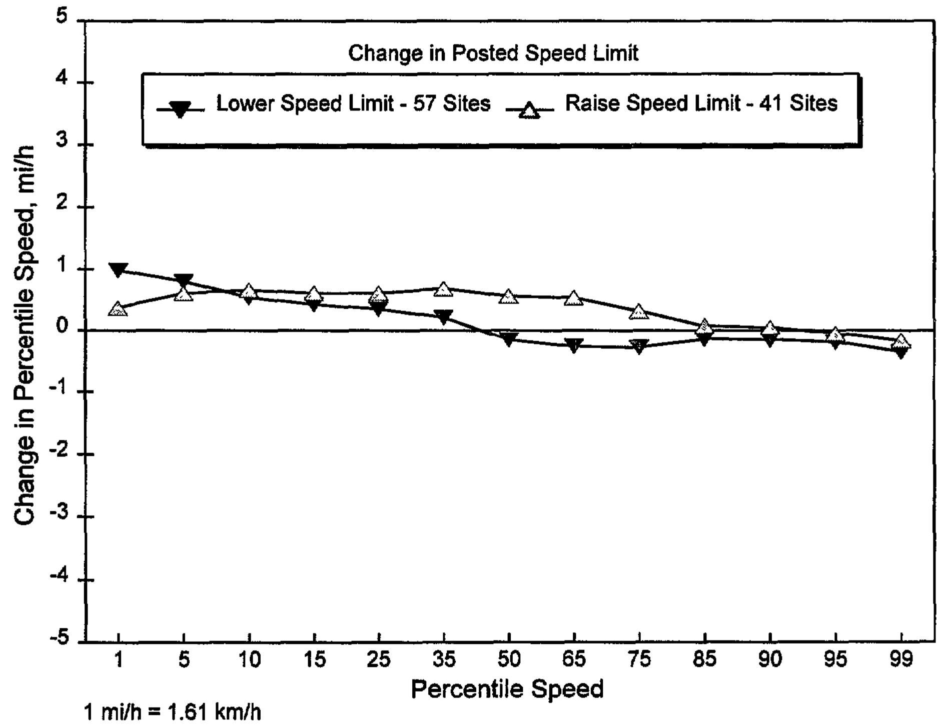


Figure 43. Mean changes in percentile speeds after speed limits were lowered at 57 sites and raised at 41 sites.

- The small differences in before and after speeds, as shown in figure 43, were statistically significant due primarily to the large sample size collected.

- At 34 locations, existing speed limits were posted within 5 mi/h (8 km/h) of the 85th percentile speeds. When speed limits at these sites were lowered more than 5 mi/h (8 km/h) below the 85th percentile speeds, the mean difference in percentile speeds was less than 1 mi/h (1.6 km/h).

- At 21 other locations, existing speed limits were posted more than 5 mi/h (8 km/h) below the 85th percentile speeds. When the agencies raised the limits to within 5 mi/h (8 km/h) of the 85th percentile speeds at these sites, the mean difference in percentile speeds was less than 1 mi/h (I .6 km/h).

- By defining driver compliance as the number or percentage of drivers that travel at or below the posted speed limit, major changes in compliance occurred when speed limits were raised or lowered. However, as reflected in small changes in vehicle speeds, driver behavior did not change, but the standard for measuring compliance, i.e., posted speed limit, changed.

- Based on the free-flow speed data collected for a 24-h period at the experimental and comparison sites in 22 States, posted speed limits were set, on average, at the 45th percentile speed or below the average speed of traffic.

- Only minor changes in vehicles following at headways of less than 2 s were found at the experimental sites with similar before and after traffic volumes.

- The indirect effects of speed limit changes on a sample of five contiguous and adjacent roadways were found to be small and insignificant.

- There is not sufficient evidence, in this dataset, to reject the hypothesis that total crashes or fatal and injury crashes changed when posted speed limits were either lowered or raised.

- There is not sufficient evidence, in this dataset, to reject the hypothesis that total crashes changed when posted speed limits were lowered more than 5 mi/h (8 km/h) below the 85th percentile speeds.

- There is not sufficient evidence, in this dataset, to reject the hypothesis that total crashes changed when posted speed limits were raised to within 5 mi/h (8 km/h) of the 85th percentile speeds.

- In April 1987, when Congress permitted States to raise speed limits to 65 mi/h (105 km/h) on selected limited access highways, speed and crash data were collected for a sample of four limited access Interstate segments. The findings concerning speed and crashes, which are different than those found on the nonlimited access roadway sites studied, are discussed in appendix G.

CONCLUSIONS

The general conclusions of this study are:

- There is statistically sufficient evidence in this dataset to reject the hypothesis that driver speeds do not change when posted speed limits are either raised or lowered. However, the differences in speeds are not sufficiently large to be of practical significance, and are due primarily to large sample sizes.

- Although the changes in vehicle speeds were small, driver violations of the speed limits increased when posted speed limits were lowered. Conversely, violations decreased when speed limits were raised. This does not reflect a change in driver behavior, but a change in how compliance is measured, i.e., from the posted speed limit.

- The majority of motorists did not drive 5 to 10 mi/h (8 to 16 km/h) above the posted speed limit when speed limits were raised, nor did they reduce their speed by 5 to 10 mi/h (8 to 16 km/h) when speed limits were lowered.

- Based on the sites selected for this study, it appears that highway agencies have a tendency to set speed limits slightly below the average speed of traffic.

- Changing posted speed limits alone, without additional enforcement, educational programs, or other engineering measures, has only a minor effect on driver behavior.

- There is not sufficient evidence in this dataset to reject the hypothesis that crash experience changed when posted speed limits were either lowered or raised.

SUGGESTIONS FOR FUTURE RESEARCH

Based on the results of this research, the following areas are suggested for further investigation:

- There is an immediate need to examine the State policies and practices used to set posted speed limits on nonlimited access facilities. In particular, attention should be given to identifying factors or a method that leads to establishing uniform speed limits for similar roadway and traffic conditions.

- The use of automated equipment and other alternative economical means of collecting unbiased speed data used to set speed limits should be explored as an alternative to the conventional use of radar.

- Actual prevailing speed data for a variety of roadway geometrics and highway systems should be summarized and provided to design engineers for use as a guideline when setting the design speed on a proposed roadway project.

- The implications of setting speed limits based on samples obtained by using an hourly or minimum vehicle requirement should be reexamined. Based on the 2-h data collection increments from the current study, as well as recent research conducted in Michigan, wide variations in the 85th percentile speeds occurred throughout the 24-h recording periods.[21] In addition, the hourly variations were not consistent from site to site. This suggests that speed samples should be taken throughout the day to obtain a representative sample of the 85th percentile speed, as opposed to collecting a sample over a short time period such as 2 h.