Operational Effectiveness of Truck Lane Restrictions

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The operational effectiveness of restricting trucks from designated lanes on multilane roadways is addressed. Three locations with no truck restrictions were treated with signing restricting trucks to certain lanes. The applied field study was of a before-and-after design (with matched control sites). Truck lane restrictions were implemented at two three-lane sites and one two-lane location. Favorable truck compliance effects were evident at all three locations. Before-and-after comparisons indicated significant truck lane use shifts; however, violation rates were higher (i.e., 10.2 percent) at the two-lane site in comparison with the three-lane sites (i.e., 0.9 and 5.7 percent). Higher violation rates at the two-lane site resulted from increased truck densities caused by restricting trucks to a single lane. An emphasis was placed on determining traffic flow effects to nontrucks in the traffic stream. Beneficial effects on three-lane roadways were realized in terms of reduced congestion and fewer trucks impeding vehicles (at both sites) and shorter following queue lengths (at one site). This finding supports the conclusion that traffic congestion at three-lane sites was reduced as the result of the restriction. An adverse effect, observed at the two-lane restriction, was reduced speeds of impeded vehicles following trucks. However, a slight benefit was found in that fewer trucks impeded following vehicles. All-vehicle speed comparisons were examined to determine whether increased differential speeds were likely to occur between the restricted and adjacent lanes. No speed changes were observed to indicate an adverse effect of the truck lane restriction.

The operational effectiveness of restricting trucks from designated lanes on a multilane roadway is addressed. Three study sites with no truck restrictions were treated with signs similar to those shown in Figure 1. The study procedure used was the before-and-after method (with matched control sites without signs). The primary measure of effectiveness (MOE) for lane restriction was voluntary truck compliance with the restriction (data were not collected in the presence of enforcement activity). Additional MOEs addressed relevant traffic flow conditions affected by the restrictions. These conditions were (a) traffic congestion as determined from speeds and platooning behaviors for vehicles following trucks, and (b) differences in speeds between the restricted and adjacent traffic lanes for all vehicles.

STUDY LOCATIONS

The truck lane restrictions were implemented at three locations designated by participating states. Two fringe-area urban sites near Chicago were restricted by extending previously existing lane restrictions. The purpose of the Chicago area lane restrictions was to improve traffic flow and operational safety. In addition, one rural, two-lane Interstate in Wisconsin was treated with a right-lane restriction because of deteriorated pavement. The Chicago restrictions prohibited trucks from using the left-hand lane of a three-lane facility, whereas the Wisconsin site restricted trucks from the right-hand lane of a two-lane roadway.

Specific site information follows.

Wisconsin

I-90/I-94 eastbound, near Lake Delton; average daily traffic 4,478, 13.4 percent trucks; restriction location Milepost 93–105; and control location 3 mi east of restriction.

Illinois

I-55 eastbound, Du Page County; average daily traffic 23,500 eastbound, 21 percent trucks; restriction location west of County Line Road; and control location 2 mi west of restriction.

I-290 eastbound, Addison; average daily traffic 78,500, 13 percent trucks; restriction location west of Wolf Road (Milepost 747.2); and control location 2 mi west of restriction.

Similar geometric alignment conditions existed at all study and control sites. These sites consisted of tangent sections with minimum sight distances of ½ mi. Sites (e.g., truck stops and industrial areas) were selected on the basis of low truck exit entry activity and were located at sufficient distance (i.e., 1-mi minimum) from ramps to effects of exit and entry activity on lane distribution.

EXPERIMENTAL APPROACH

The approach used was a before-and-after study with control sites. Identical behavioral observations were made at geometrically matched nonrestricted (control) sections on the same highway as the restricted (test) sites. Locations of sites within designated pairs, each containing an upstream control section, virtually ensured measurement of the same truck sample at the test and control locations.

Data collection was conducted on weekdays and was strictly controlled for a time-of-day match between before and after conditions. In order to minimize seasonal, traffic volume, and traffic mix effects, an attempt was made to conduct before and after observations exactly 52 weeks apart. However, this feature was not possible for one site (I-290 in Chicago) because of state agency timing for implementing the new restriction. Yet, concurrent observations at the matched control site did ensure the integrity of the applied experimental procedures.

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FIGURE 1 Applied truck restriction signing in the Chicago area.

MOEs

Applied operational MOEs for evaluating the three cases of truck lane restrictions were

- Truck lane occupancy,
- Delay to following vehicles,
- Proportion of trucks impeding followers, and
- Adjacent lane speed differential.

The following is a brief discussion of field measurement procedures and significance of these MOEs.

Truck Lane Occupancy

Because the regulatory intent of the lane restriction was to preclude trucks from designated lanes, compliance measures consisted of truck counts by lane before and after the restriction was placed in effect. Manual counts were conducted at restricted and nearby control sites. Before-and-after observations were matched by time-of-day and day-of-week.

Delay to Following Vehicles

Operational effects of restricting trucks to certain lanes involve highway capacity and congestion. Thus, the target was not truck speeds per se, but rather speeds and queuing (i.e., platooning) characteristics of vehicles in the stream that were affected by trucks. The primary operational concern associated with restricting trucks to specific lanes is whether greater delays and longer queues occur in nonrestricted lanes for vehicles following trucks.

The data collection approach used is shown in Figure 2. Results from previous research (*1*) have determined specific vehicle following distances associated with free-flow speeds. Absence of a free-flow condition results in the queuing of vehicles because the speeds of following vehicles are impeded by leading vehicles. Therefore, the lane restriction sites were instrumented to support visual observation to determine whether vehicles following trucks were queued or free-flow conditions existed. Unobtrusive roadside markers were applied to measure the number of queued vehicles following target trucks. When a second truck was queued behind a lead truck, it merely counted as a queued vehicle. Referring to Figure 2, counts were made of following vehicles with headways less than *P*, the following distance associated with platooning in the absence of free-flow conditions. A following vehicle with a headway equal to or greater than *P* signified the end of the queue.

Speeds for the queues were determined using a modified version of the radar-platooning technique (*2*). Because radar could be detected by truck operators and consequently bias results, manual speed timing was applied to measure speeds for vehicles following trucks (i.e., given that the observed headway was less than *P*). The speed timing procedure applied had been previously validated and produced a sample accuracy of 0.1 mph (*3*). Application of these procedures for measuring platoon speed involved clocking speeds of the lead vehicle and multiplying by the number of queued vehicles to determine a weighted mean speed for the overall sample.

Proportion of Trucks Impeding Followers

An applied measure of congestion is the before-and-after proportions of trucks that impeded following vehicles. As can be seen from Figure 2, when no vehicle is within following distance behind a target truck, this truck is not impeding a follower. This measure provided a basis for examining the operational effect of less congestion attributed to greater ease of passing trucks in a lane-restricted flow situation. The pro-

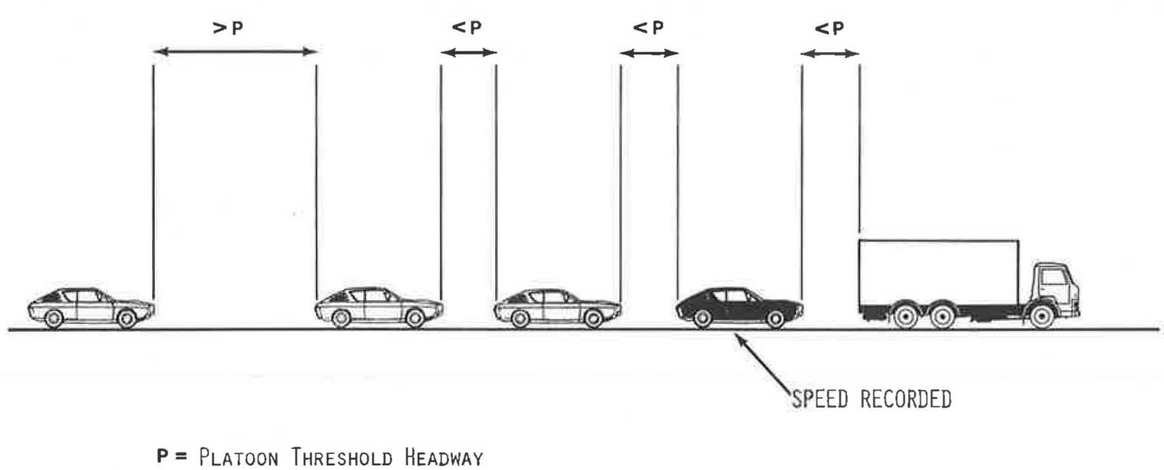

FIGURE 2 Designated vehicles for field data collection.

portion of trucks associated with zero queue lengths represents those trucks not impeding following vehicles.

Differential Speeds Between Lanes

Large differential speeds between restricted and adjoining traffic lanes are a safety concern because of the increased accident potential for vehicles that change lanes. Therefore, a major operational issue in the assessment of restricted truck lanes is whether an increased speed difference results between restricted and adjacent, nonrestricted lanes. This safety concern evolves from two potential operational effects that cause increased differential speeds between restricted and adjacent lanes: (a) absence of trucks may produce an overall speed increase in the restricted lane, and (b) an increase in number of trucks may result in a decrease in speed in the adjacent lane.

Differential speeds between lanes represent a safety hazard (or accident potential) under conditions of sufficient traffic density. The following two conditions can be used to measure any potential effect: (a) presence of trucks influencing overall stream speeds, and (b) presence of improper lane changing. The data collection procedure applied to determine the MOE for speed differences was all-vehicle speed sampling in the restricted and adjacent lanes.

RESULTS

Data for primary MOEs (truck lane occupancy, trucks impeding followers, and following vehicle delay) were gathered at all three truck lane restriction locations. The MOE for differential speed between lanes required sufficient left-lane traffic volume that removal of trucks could be expected to affect all-vehicle speeds. For this phenomenon to occur, a sufficiently high traffic volume was necessary to permit vehicle interactions between trucks and other vehicles. This prerequisite traffic condition existed at only one of the test sites. Therefore, results based on lane occupancy, trucks impeding followers, and following vehicle delay are discussed separately from results based on between-lane speed differentials.

Based on Lane Occupancy, Trucks Impeding Followers, and Follower Delay MOEs

The two Chicago area study conditions were left-lane restrictions on three-lane roadways, whereas the Wisconsin site comprised a right-lane restriction on a two-lane roadway.

I-290, Chicago Area

Before-and-after comparisons for the following traffic flow parameters were observed for test and control site pairs.

- Average Hourly Traffic Volume. Total vehicle volumes were estimated on the basis of 5-min periods of continuous counting during each hour of traffic observation.
- Truck Distributions. Observed truck counts (and percentages) by lane, indicating which lane was restricted in the after condition.
- Following Vehicle Speeds. As previously indicated from Figure 2, speeds of vehicles queued behind trucks were obtained by means of the platoon-weighting technique.
- Following Queues. Average number of queued vehicles behind observed trucks is given as a measure of before-and-after traffic congestion.
- Truck Proportion Impeding Followers. Proportion of trucks in the stream characterized by platooned vehicles queued behind them.

Before-versus-after truck occupancy by lane was seasonally affected by an increase in traffic volume. Observed traffic volume increases were approximately 23 and 13 percent at the restricted and control sites, respectively. These differences contributed to an increase in truck occupancy of the left lane at the control site from 3.8 to 5.4 percent; however, a concurrent slight reduction of left-lane occupancy, from 6.7 to 5.8 percent, was observed at the restricted site. This relative difference in directionality between the test and control locations was caused by the lane restriction.

Although neither of the before-and-after truck lane occupancy shifts at either the test or control site was statistically significant taken separately (from application of z-test of proportions), combined effects considering changes at both locations (from application of chi-squared contingency tests) demonstrated statistical significance at the 99 percent confidence level.

An application of the chi-squared statistic did reveal differences between the test and control sites during the before condition. Application of the odds ratio directly compared the probability of left-lane traffic presence between the test and control sites (i.e., an odds ratio of 1.775, with a standard error of 0.2962, indicated a factor of 1.775 greater probability of a truck's being in the left lane at the test site). However, the same statistical procedure applied to data collected in the after condition indicated a nearly equal likelihood of left-lane truck occupancy at either the test or control site. The combined effect determined from these two observations is that

TABLE 1 BEFORE-AND-AFTER CHANGES FOR CHICAGO AREA I-290 SITE

Site	Average Hourly Truck Volume (%)	Right-Lane Truck Distribution (%)	Following-Vehicle Speed (mph)	Following Queues (veh)	Truck Fraction Impeding Followers (%)
Control	+13.0	+1.6	−0.6	+0.43	+15.2
Test	+23.0	−0.9[a]	−0.7	+0.14[a]	+3.2[a]

[a]Significant treatment effect.

the lane restriction applied at the test site was effective at reducing left-lane truck usage.

Average flow delay to vehicles impeded by trucks was recorded both at the test and control locations. Small average speed reductions between before and after conditions (0.6 mph at the control site and 0.7 mph at the restricted site) were statistically significant at the 0.01 probability level. This change is interpreted as a general slowing because of the traffic volume increase during the after condition.

In order to illustrate the effect on vehicle queuing behind trucks, Figure 3 shows before-and-after percentage distributions for observed queue lengths both at the control and test sites. Of particular interest is the proportion of trucks that do not impede following vehicles, i.e., of trucks characterized by a zero length of following queue. At the control site, a significantly smaller proportion of zero queue length, 37.2 versus 45.4 percent, signifying a more congested condition, was observed during the after condition; whereas no significant differences in queuing were observed at the test site. Thus, a benefit of the lane restriction was realized in terms of no corresponding increase in queuing at the test site.

The zero-queue proportional differences were statistically determined by application of the z-test. Chi-squared tests applied to overall queuing distributions confirmed generally longer queues in the after condition at the control site. This demonstrated operational effect shows that restricting trucks to the right-hand two lanes improved the passing ability of following vehicles. Although more congestion (e.g., longer mean queue lengths) was observed both at the test and control sites because of higher traffic volumes in the after condition, the relative increase (i.e., greater congestion at the control site) provides additional evidence of the effectiveness of truck lane restrictions.

Table 2 presents results of the data analysis previously discussed for the I-290 site pair. The operational effect of the lane restriction was a decrease in left-lane truck occupancy, shorter queues following trucks, and fewer trucks impeding following vehicles. A greater relative following queue length reduction was observed at the test site (by comparison with the control) despite a larger increase in traffic volume. Thus, the demonstrated benefit of the truck lane restriction was an overall traffic congestion reduction. No sustained effect on speeds of vehicles following trucks was attributable to the lane restriction.

I-55, Chicago Area

Observations were made at a second Chicago area truck lane restricted site. I-55 is characterized by a lower traffic volume condition in which no left-lane trucks were observed at either the test or control sites during the before condition. As pre-

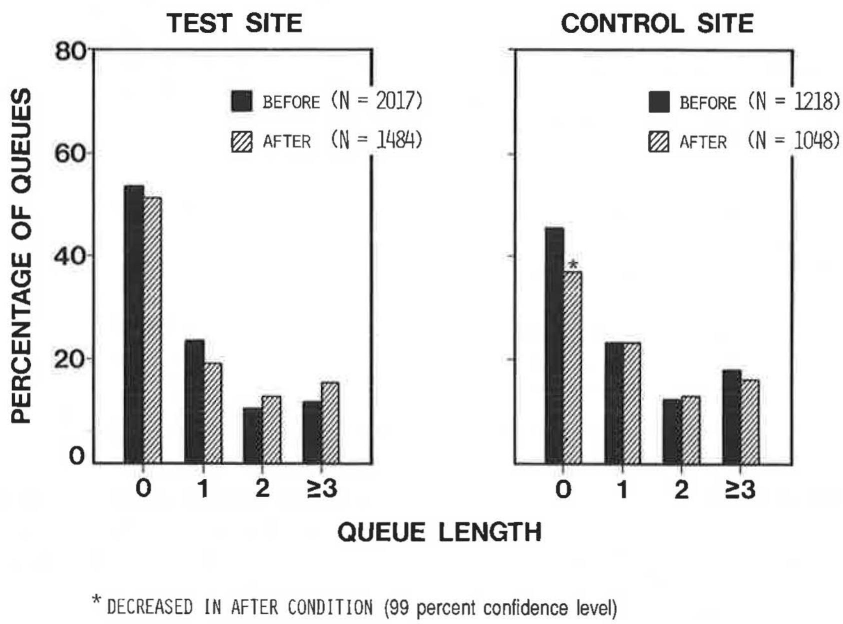

FIGURE 3 Before-and-after queue length distributions for I-290, Chicago site pair.

TABLE 2 BEFORE-AND-AFTER CHANGES FOR CHICAGO AREA I-55 SITE

Site	Average Hourly Truck Volume (%)	Right-Lane Truck Distribution (%)	Following-Vehicle Speed (mph)	Following Queues (veh)	Truck Fraction Impeding Followers (%)
Control	+21.0	+2.1	−0.6	−0.01	−6.2
Test	+7.0	+0.9[a]	−2.7	−0.07	−11.8[a]

[a]Significant treatment effect.

viously noted for the I-290 site, an increase in traffic volume affected truck presence in the left (restricted) lanes during the after condition. However, application of the chi-squared statistic indicated that the probability of a truck's being in the left lane during the after condition at the restricted site was only 0.43 that of being in the left lane at the control site. This analysis demonstrates a favorable effect of decreased truck usage of the restricted lane.

Also, as in the case of I-290 site pairs, similar flow differences were observed between before and after conditions both at the test and control locations. Both for the test and control sites, slight but statistically significant speed increases were noted for vehicles queued behind trucks. This effect may be expected to accompany less stable flow associated with higher traffic volumes. However, similar differences occurring at both the test and control sites substantiate that no detrimental flow effects were attributable to implementation of the lane restrictions.

Speed changes of vehicles following trucks both at the test and control sites were examined for a possible effect of the lane restriction. However, observed differences could be attributed to the before-and-after traffic volume increase rather than truck lane restriction effects.

Before-and-after queuing differences for vehicles impeded by trucks can be seen in Figure 4, which shows plots of before-and-after frequency distributions for the test and control sites. The before-and-after proportion of trucks not impeding other vehicles increased from 44.9 to 51.4 percent at the test site, whereas no significant change was observed at the control site. Although following-vehicle queue lengths were less varied in the after condition, the observed tendency to relatively shorter queues (by comparison with the control site) could not be statistically sustained as a benefit of the restriction. However, the overall improved flow condition, characteristic of a less congested situation, is attributed to implementation of the truck lane restriction.

Data analysis results are presented in Table 3. Lane restriction effects observed at I-55 were consistent with I-290 findings—significantly reduced truck usage of the left lane was accompanied by fewer trucks impeding following vehicles. Thus, the resulting operational effect was reduced overall traffic congestion attributable to implementation of the lane restriction.

I-90/I-94, Wisconsin

Traffic conditions were observed at a third site pair on I-90/I-94 near Madison, Wisconsin. This restriction test differed from that in Chicago area sites in that the site consisted of a two-lane geometry with a right-lane restriction. Thus, the before condition was characterized by 87.4 percent of the observed trucks in the restricted lane. An observed truck percentage reduction to 10.2 percent in the after condition was significant, and no concurrent reduction occurred at the control site.

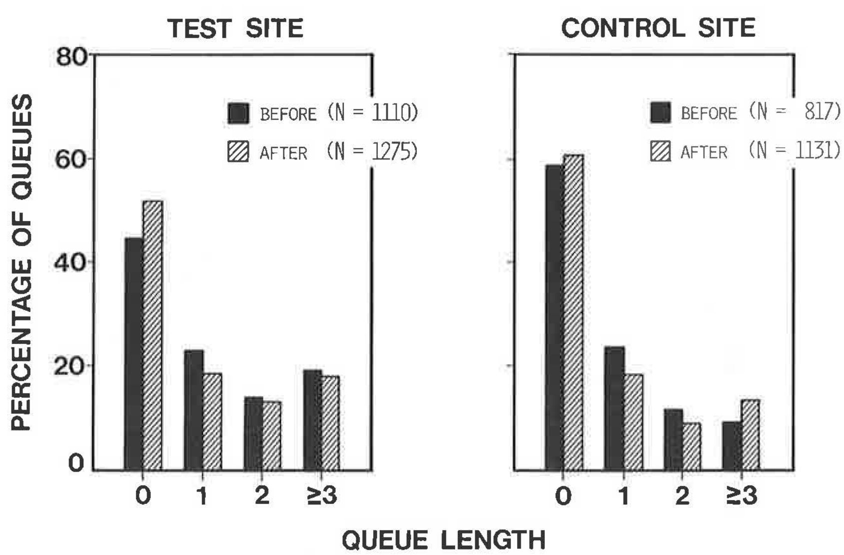

FIGURE 4 Before-and-after queue length distributions for I-55, Chicago site pair.

TABLE 3 BEFORE-AND-AFTER CHANGES FOR I-90/I-94 WISCONSIN SITE

Site	Average Hourly Truck Volume (%)	Right-Lane Truck Distribution (%)	Following-Vehicle Speed (mph)	Following Queues (veh)	Truck Fraction Impeding Followers (%)
Control	−4.2	−4.3	+1.2	−0.11	−23.4
Test	−6.7	−77.2[a]	−1.4[a]	−0.09	−25.1

[a]Significant treatment effect.

Violations consisting of trucks traveling in the restricted lane of the right-lane restriction (10.2 percent) were more frequent than those observed at either Chicago left-lane site (i.e., 5.7 and 0.9 percent, respectively). However, this result was caused by the restricting of a two-lane as opposed to a three-lane roadway geometry. Because the study sites were characterized by substantial truck volumes, less compliance could be expected at a two-lane site because of the necessary crowding of trucks.

A slight, but statistically significant, overall speed decrease in the after condition was observed for impeded vehicles following trucks at the test site. This effect was caused by the denser truck traffic that was restricted to a single lane. This speed decrease is especially noteworthy in view of a concurrent speed increase observed at the control site. Reversal of following-vehicle speeds (i.e., faster at the control and slower at the restriction) was not observed at either Chicago site.

Lane-specific speed analyses for following vehicles indicated a major expected effect of the right-lane truck restriction—significant slowing in the left lane was associated with the increased truck presence. However, trucks remaining in the right-hand lane at the test site that violated the restriction also exhibited reduced speeds in the after condition. This effect was associated with the lane restriction. The opposite effect (i.e., increased right-lane speeds) was observed at the control. Two likely explanations of the speed reduction at the test site were (a) restricted passing opportunities, and (b) driver uncertainty resulting from high left-lane truck presence that violated driver expectation for the lane carrying slower-moving vehicles.

Overall following-vehicle speed reductions were seen as an operational effect of restricting trucks from the right-hand lane. Increased left-lane truck congestion restricted passing opportunity and created uncertainty for those vehicles queued behind remaining right-lane trucks. These effects are viewed as negative impacts of the right-lane truck restriction.

Figure 5 shows before-and-after queue length distributions at the test and control sites. Significantly larger percentages of trucks were observed not to impede following vehicles during the after condition both at the test (79.7 versus 72.1 percent, respectively) and control (79.0 versus 72.6 percent, respectively) sites. Although this result is likely because of lower truck volumes, a slightly stronger statistical relationship (from application of the omega-squared statistic) was noted at the test site. Thus, the finding of less queuing behind trucks, noted at the previously discussed sites, also applies to the Wisconsin site pair.

Results of the Wisconsin site data analysis are presented in Table 4. Although implementation of a right-lane truck restriction was effective in eliciting a significant shift in truck lane presence, certain adverse effects (e.g., greater slowing of following traffic) likely resulted from restricted passing opportunity because of the crowding of trucks into the left lane. Therefore, the congestion-reducing benefit previously observed with truck restrictions imposed on a three-lane roadway was less evident in this two-lane situation. Finally, an inherent concern with a two-lane restriction is increased violation rates and congestion associated with higher truck volumes.

Based on the MOE of Differential Speed Between Lanes

Before-versus-after speeds were investigated to determine whether restricting trucks from one lane increased the speed differential between that and the adjacent lane.

Of the three truck lane restrictions, two were characterized by sufficiently low traffic volumes and densities that did not exert an influence on overall traffic speeds. Therefore, the differential speed study was limited to a one-lane restriction site pair (on I-290, near Chicago).

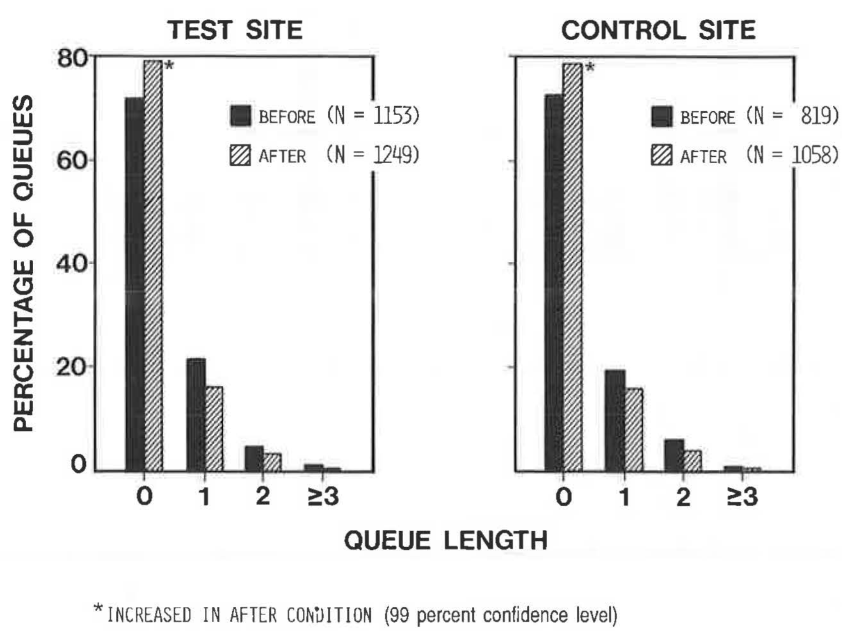

FIGURE 5 Before-and-after queue length distributions for I-90/I-94, Wisconsin site pair.

TABLE 4 ALL-VEHICLE SPEEDS OBSERVED ON RESTRICTED AND NONRESTRICTED EXPRESSWAY SECTIONS NEAR CHICAGO

	Restricted Lane				Adjacent Lane			
	N	Mean (mph)	Standard Deviation (mph)	99 Percent Confidence Interval (mph)	*N*	Mean (mph)	Standard Deviation (mph)	99 Percent Confidence Interval (mph)
Test								
Before	434	62.2	4.66	0.52	567	59.3	4.63	0.45
After	442	60.6[a]	4.69	0.51	671	58.4[a]	4.18	0.38
Control								
Before	511	64.6	4.32	0.44	587	59.7	3.67	0.35
After	461	62.0[a]	4.03	0.44	643	58.7[a]	4.04	0.37

[a]Significant change between before and after condition at the 99 percent confidence level.

The study procedure involved sampling all-vehicle speeds (in which any vehicle, regardless of type, had an equal probability for inclusion into the sample) both in the restricted lane and adjacent lane at various times throughout two separate days both in the before and after conditions. Observations were limited to stable and free-flow conditions (at Level of Service C or better). During unstable or forced-flow conditions, the effect of differential speed would have been masked, thereby rendering impossible measurement of any effect of the restriction. Speeds were manually timed by electronic stopwatch. A randomization procedure was applied to eliminate coder bias in selecting vehicles for speed measurement. This technique had been previously validated and found to produce sample results within 0.1 mph of all-vehicle population speeds (*3*).

Summary speed observations are presented in Table 5. Sufficient sample sizes were gathered at all locations to support mean speed determination with an accuracy of 0.5 mph at the 99 percent confidence level. Controlled day-of-week and time-of-day observations ensured uniformity of flow conditions between before and after periods. Thus, any seasonal effect was controlled by application of the test and control site study design.

Table 5 indicates that mean speeds were significantly lower both at the test and control sites in the after period. Weighted average speeds (considering relative volumes of the restricted and adjacent lanes) were approximately 1.9 mph lower at the control site and 1.3 mph lower at the test site. No differences in overall speed variation were observed. The apparent volume-related effect of lower mean speeds exceeded any observable effect of the truck restriction. Observed mean differential speeds between restricted and adjacent lanes for the before and after conditions are as follows:

Scenario	*Test (mph)*	*Control (mph)*
Before	2.9	4.9
After	2.2	3.3

An adverse effect of truck lane restrictions was an overall speed increase in the left lane accompanied by a possible speed reduction in the adjacent lane. This occurrence would produce higher differential between-lane speeds and a possibly greater accident hazard. However, as noted previously, a general speed reduction was observed in the after condition; furthermore, speed differences across lanes did not increase. Therefore, no adverse speed effect could be attributed to the shift in truck occupancy.

Mean lane-specific changes between the before and after conditions are as follows:

Lane	*Test (mph)*	*Control (mph)*
Restricted	−1.6	−2.6
Adjacent	−0.8	−1.0

Although significant before-and-after speed decreases were greater in the left lane, the change was less pronounced at the test site. This finding indicates no adverse effect of the lane restriction in mean speed change because safety (as associated with smoother flow) is enhanced by the less severe before-and-after speed difference.

DISCUSSION OF RESULTS

Truck lane restrictions were implemented at two three-lane sites and one two-lane location. The left lane was restricted at the three-lane sites, whereas the right lane was restricted at the two-lane location. Timing and locations of observed restrictions depended on state highway agency decisions and could not be controlled.

Favorable truck compliance was evident at all three restriction locations. Before-and-after comparisons, undertaken at matched test and control site pairs, indicated significant truck lane changes in compliance with all three restrictions. However, violation rates were 10.2 percent higher at the two-lane site versus 0.9 and 5.7 percent higher at the three-lane sites. This lower level of compliance likely resulted from high truck concentrations, because of the restricting of trucks to a single lane. No indication was found that differential compliance behavior was associated merely with left- versus right-lane restrictions.

The emphasis of the procedure was to determine flow effects to nontruck vehicles in the traffic stream. The primary MOE was delay to impeded vehicles. Beneficial traffic flow effects resulted from lane restrictions applied to three-lane roadways. Under this geometric condition, reduced traffic congestion was realized in terms of fewer trucks' impeding vehicles at both sites and shorter following queue lengths at one of the two sites. This finding is based on relative effects between matched test and control site pairs. MOEs related to traffic flow (such as impeded queue lengths) benefitted despite increased traffic volumes in the after condition that would ordinarily suggest degraded flow conditions. The observed improvement in flow was further evidence of the benefit of the truck lane restriction. The significance of this finding is that implementation of truck lane restrictions at three-lane sites did achieve the generally intended goal of reducing the overall level of congestion.

An adverse flow effect observed at the site with the two-lane, right-hand-lane restriction was reduced speeds of impeded vehicles following trucks. Operational causes of this finding were crowding of trucks into the left lane in combination with limited passing opportunity for remaining right-lane truck followers. Concurrent control site observations confirmed that this effect was because of implementation of the restriction. A weak statistical finding indicated a slight benefit in that fewer trucks impeded following vehicles at the two-lane site.

All-vehicle speed comparisons were examined at one location to determine whether increased differential speeds were likely to occur between the restricted and adjacent lanes. This investigation was prompted by a concern that overall speeds would increase in the restricted lane and decrease in the adjoining lane. No speed changes were observed to indicate an adverse effect of implementing the truck lane restriction.

CONCLUSION

Beneficial traffic flow effects (e.g., reduced congestion) associated with left-lane truck restrictions on three-lane roadways support their continued use. However, findings including high violation rates and slowing of impeded vehicles associated with the two-lane site restriction raise safety issues that warrant an accident study or other further investigation.

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