Accident Effects of Centerline Markings on Low-Volume Rural Roads

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ABSTRACT

Several accident comparisons were made for low-volume rural roads that were either unmarked, marked with a dashed centerline only, or marked with both a dashed centerline and no-passing zone stripes. These analyses made use of the Federal Highway Administration data base collected during the Pavement Marking Demonstration Program. The analyses indicated that the Pavement Marking Demonstration Program as a whole was not effective in reducing highway accidents. However, the analyses indicated that the safety effects that resulted from adding combined centerlines may be beneficial for pavement widths of 20 or more feet and traffic volumes of 500 or more vehicles per day.

In designing and operating highways, the highway agency is interested in providing maximum traffic safety and efficiency. Maximum safety requires wide roadways and shoulders, gentle alignment, clear roadsides, and high quality traffic control devices.

When considering low-volume rural roads, however, the highway agency is faced with an apparent dilemma. On the one hand, the agency would like to provide each individual motorist with the same degree of safety experienced on the modern Interstate system. On the other hand, the cost of providing this degree of safety often conflicts with the agency's philosophy of economic expediency. The way to solve this apparent dilemma is to gain knowledge of the safety effects of each highway design and traffic control element so the application of criteria can be established through the principles of cost-effectiveness.

The use of centerline and no-passing zone markings is one area where the cost-effectiveness is unclear. For example, the Manual on Uniform Traffic Control Devices (1) does not give a guideline on the minimum traffic volume level for the application of centerline markings. For no-passing zone markings, the manual mandates them on all highways where centerlines are used.

In a report published by the NCHRP, probability analyses and assumptions about accident reduction were used to conclude that centerline markings are not cost-effective below 300 vehicles per day (vpd) (2). What is needed is a more definitive empirical study that either substantiates or modifies these findings. The objective of this research was to collect and evaluate accident data for the purpose of verifying or modifying the warrants for centerline and no-passing zone markings suggested in the NCHRP Report.

EFFECTIVENESS OF ADDING CENTERLINE AND NO-PASSING ZONE MARKINGS TO UNMARKED HIGHWAYS

Of primary interest in this project was the determination of any accident benefits associated with the placement of centerline and no-passing zone markings on low-volume rural roads. A review of published literature revealed the lack of any descriptive data. The 1981 and 1982 editions of the Federal Highway Administration (FHWA) report on highway safety stewardship (3,4) did provide a general overview of the Pavement Marking Demonstration Program (PMDP) that was established by the Federal Highway Act of 1973. Table 1, which is extrapolated from these documents, contains data on the net accident effect on the application of centerline and no-passing zone markings on previously unmarked highways. As can be seen from this table, the general accountability of the PMDP is a significant increase in injury accidents, a significant decrease in property-damage only accidents (PDO), and no significant change in total accidents.

TABLE 1 Accident Reduction Effectiveness for the PMDP Application of Centerline and No-Passing Zone Markings *(3,4)*

Year	No. of States	No. of Miles	Total Cost (million $)	Reduction in Accidents[a] (%)			
				Fatal	Injury	Property Damage Only	Total
1980	14	11,475	4.416	-8	-8[b]	2[b]	-1
1981	15	12,673	5.039	-3	-6[b]	4[b]	1

[a]Minus sign denotes increase.
[b]Significant change at 95 percent level of confidence.

In an attempt to find more descriptive data regarding the evaluation of pavement marking effectiveness, several unpublished documents were found. Most helpful of these was a Federal Highway Administration (FHWA) report by Lee (5), which contained an evaluation of 225 pavement marking projects in six states. A brief summary of this evaluation is given in Table 2. Although the statistical significance of these evaluations was not given, all pavement marking categories showed an increase in accident rate. On request, the FHWA supplied the original data base for the Lee report. In addition to before and after accident data for each project, the data base also included highway information on project length, before and after study periods, average daily traffic (ADT), lane width, shoulder width, terrain, and speed limit.

Additional data was obtained from several states. However, some of these data sets were not descrip-

TABLE 2 Summary of PMDP Effectiveness Report by Lee *(5)*

Improvement Type	No. of Sites	No. of Miles	Accident Rate (A/MVM)[a] Before	After	Change (%)
Centerline striping	48	382	4.18	4.28	+2
Edgeline striping added	94	721	2.88	2.93	+2
Centerline and edgeline	83	943	1.97	2.55	+29
Total	225	2,046	2.64	2.99	+13

[a]A/MVM = accidents per million vehicle miles.

tive enough for additional analysis, and other data sets were from states already included in the FHWA data base. As a result, only data sets from Ohio and Missouri were used in additional analyses. The data from Missouri provide the only available analysis of the effectiveness of adding dashed centerlines only to unmarked highways and the effectiveness of adding no-passing zone markings to highways marked with either dashed centerlines only or with dashed centerlines and edgelines.

Table 3 contains results of a general analysis of the effectiveness of adding centerline and no-passing zone markings to previously unmarked highways. This table includes the five states with this kind of project in the FHWA data base as well as Ohio. This table shows somewhat mixed results. The data for indicated significant increase in accidents and the data for Ohio indicated a significant decrease in accidents, while the other four states showed nonsignificant differences. These six states may, however, have different reporting levels, ADT distributions, and road design characteristics in their samples of projects.

The significance test used in Table 3 and all subsequent tables is a one-sample t-test using a normal approximation to a binomial distribution. In essence, it tests whether the proportion of before or after accidents to total accidents is significantly different than the proportion of before of after vehicle-miles to total vehicle-miles. The statistic is as follows:

$$t = A_B M_A - A_A M_B / [(A_B + A_A) M_A M_B]^{1/2} \quad (1)$$

where

A_B = number of accidents in before period,

TABLE 3 Summary of Before and After Accident Statistics for Projects Where Centerline and No-Passing Markings Were Added to Previously Unmarked Highways

State	No. of Sites	No. of Miles	Before Period: Vehicle Miles (millions)	Before Period: No. of Accidents	Before Period: Accident Rate	After Period: Vehicle Miles (millions)	After Period: No. of Accidents	After Period: Accident Rate	Significant Difference[a]
FHWA Data Base									
Missouri	4	27.80	13.140	45	3.42	11.308	33	2.92	N.S.
Montana	2	20.30	3.482	10	2.87	2.449	24	9.80	S(+)
North Carolina	13	96.90	29.775	127	4.27	30.457	150	4.92	N.S.
Virginia	22	168.11	30.628	151	4.93	33.180	168	5.06	N.S.
West Virginia	7	68.70	36.321	144	3.96	39.233	141	3.59	N.S.
Total	48	381.81	113.346	477	4.21	116.627	516	4.42	N.S.
Ohio Data Base									
Ohio	N/A	468.24	92.870	153	1.65	94.360	106	1.12	S(-)
Grand total	N/A	850.05	206.216	630	3.06	210.987	622	2.95	N.S.

Note: N.S. = nonsignificant.

[a]Significance at 90 percent confidence level using two-tailed t-test.

TABLE 4 Summary of Before-After Injury Plus Fatal Accident Statistics for Projects Where Centerline and No-Passing Markings Were Added

State	No. of Sites	No. of Miles	Before Period: Vehicle Miles (millions)	Before Period: No. of Fatal and Injury Accidents	Before Period: Fatal and Injury Accident Rate	After Period: Vehicle Miles (millions)	After Period: No. of Fatal and Injury Accidents	After Period: Fatal and Injury Accident Rate	Significant Difference[a]
FHWA Data Base									
Missouri	4	27.80	13.140	20	1.52	11.308	15	1.33	N.S.
Montana	2	20.30	3.482	8	2.30	2.449	11	4.49	N.S.
North Carolina	13	96.90	29.775	48	1.61	30.457	52	1.71	N.S.
Virginia	22	168.11	30.628	52	1.70	33.180	66	1.99	N.S.
West Virginia	7	68.70	36.321	42	1.16	39.233	47	1.20	N.S.
Total	48	381.81	113.346	170	1.50	116.627	191	1.65	N.S.
Ohio Data Base									
Ohio	N/A	468.24	92.870	59	0.64	94.360	42	0.45	S(-)
Grand total	N/A	850.05	206.216	229	1.11	210.987	233	1.10	N.S.

Note: N.S. = nonsignificant.

[a]Significance at 90 percent confidence level using two-tailed t-test.

A_A = number of accidents in after period,
M_B = number of vehicle-miles in before period, and
M_A = number of vehicle-miles in after period.

In Table 4, the same data as in Table 3 are used to show before-after comparisons for fatal plus injury accidents. In this case, Ohio is the only state that shows a significant change, a decrease in severe accidents.

In an attempt to understand some of the variances shown in Tables 1 through 4, several analyses were conducted on the FHWA data base, where information was available on highway characteristics for each project. These analyses showed state, ADT, and lane width to be the only interesting stratification variables. Also, total accident comparisons and fatal plus injury accident comparisons showed similar results, so only the total accident comparisons are shown.

The data in Table 5 give a summary of the FHWA data base stratified by ADT. In this table, the data for Montana indicate a significant increase in accident rate for ADTs of 0-500 vpd, and the data for North Carolina indicate a significant increase in accident rate for ADTs of 501-1,000 vpd. The totals for each ADT category are nonsignificant but show a trend toward accident benefits with higher ADTs.

The data in Table 6 give a summary of the FHWA data base stratified by lane width. In this table, Montana shows a significant increase in accident rate for lane widths of between 10 and 11 ft. All other comparisons indicate no significant differences.

In an attempt to find a more discerning relationship for the accident effectiveness of centerline

TABLE 5 Summary of Before-After Accident Statistics Stratified by ADT for 48 Projects Where Centerline and No-Passing Zone Markings Were Added (FHWA data base)

State	No. of Projects	Before Period: Vehicle Miles (millions)	Before Period: No. of Accidents	Before Period: Accident Rate	After Period: Vehicle Miles (millions)	After Period: No. of Accidents	After Period: Accident Rate	Significant Difference[a]
ADT = 0-500 VPD								
Missouri	1	1.205	9	7.47	1.009	3	2.97	N.S.
Montana	2	3.482	10	2.87	2.449	24	9.80	S(+)
North Carolina	9	13.347	53	3.97	13.661	50	3.66	N.S.
Virginia	15	15.831	73	4.61	16.400	88	5.37	N.S.
Total	27	33.865	145	4.28	33.519	165	4.92	N.S.
ADT = 501-1,000 VPD								
Missouri	1	1.900	15	7.89	1.900	10	5.26	N.S.
North Carolina	4	16.428	74	4.50	16.796	100	5.95	S(+)
Virginia	4	5.981	31	5.18	6.402	31	4.84	N.S.
West Virginia	3	4.031	14	3.47	4.059	23	5.67	N.S.
Total	12	28.340	134	4.73	29.157	164	5.62	N.S.
ADT = >1,000 VPD								
Missouri	2	10.035	21	2.09	8.399	20	2.38	N.S.
Virginia	3	8.816	47	5.33	10.378	49	4.72	N.S.
West Virginia	4	32.290	130	4.03	35.174	118	3.35	N.S.
Total	9	51.141	198	3.87	53.951	187	3.47	N.S.

Note: N.S. = nonsignificant.

[a]Significance at 90 percent confidence level using two-tail t-test.

TABLE 6 Summary of Before-After Accident Statistics by Lane Width for 48 Projects Where Centerline and No-Passing Markings were Added (FHWA data base)

State	No. of Projects	Before Period: Vehicle Miles (millions)	Before Period: No. of Accidents	Before Period: Accident Rate	After Period: Vehicle Miles (millions)	After Period: No. of Accidents	After Period: Accident Rate	Significant Difference[a]
Lane Width of 8-9 ft								
North Carolina	11	23.436	87	3.71	23.983	110	4.59	N.S.
Virginia	19	24.776	114	4.60	26.360	128	4.86	N.S.
West Virginia	7	36.321	144	3.96	39.233	141	3.59	N.S.
Total	37	84.533	345	4.08	89.576	379	4.23	N.S.
Lane Width of 10-11 ft								
Missouri	4	13.140	45	3.42	11.308	33	2.92	N.S.
Montana	2	3.482	10	2.87	2.449	24	9.80	S(+)
North Carolina	2	6.339	40	6.31	6.474	40	6.18	N.S.
Virginia	3	5.852	37	6.32	6.820	40	5.87	N.S.
Total	11	28.813	132	4.58	27.051	137	5.06	N.S.

Note: N.S. = nonsignificant.

[a]Significance at 90 percent confidence level using two-tail t-test.

and no-passing zone markings, the FHWA data were stratified by both ADT and lane width. For this purpose, two separate analyses were undertaken. The first analysis used the 48 before-after sites shown in previous tables. The second analysis, which is not entirely a before-after comparison, used portions of data from all 225 projects in the FHWA data base where either no markings were present or centerline and no-passing zone markings were present.

The data in Tables 7 and 8 give the 48 before-after projects stratified by ADT and lane width. These tables show significant increases in accident rate for highways with up to 500 vpd, a lane width of between 10 and 11 ft, and for highways with between 501 and 1,000 vpd and a lane width of between 8 and 9 ft. Although all other categories are nonsignificant, there does appear to be a decided trend toward accident rate decrease with higher ADTs and wider lanes.

The data in Tables 9 and 10 give a comparison from the FHWA data base of all sites with no markings in the before period to all sites with centerline and no-passing zone markings in either the before or after period. These tables also show significant increases in accident rate for highways with up to 500 vpd and a lane width of between 10 and 11 ft, and for highways with between 501 and 1,000 vpd and a lane width of between 8 and 9 ft.

TABLE 7 Comparison of Before-After Accident Statistics by ADT for Sites with 10-11 ft Lanes Where Centerline and No-Passing Zone Markings were Added (FHWA data base)

		Before Period			After Period			
ADT by State	No. of Sites	Vehicle Miles (millions)	No. of Accidents	Accident Rate	Vehicle Miles (millions)	No. of Accidents	Accident Rate	Significant Difference[a]
ADT = 0-500 VPD								
Missouri	1	1.205	9	7.47	1.009	3	2.97	N.S.
Montana	2	3.482	10	2.87	2.449	24	9.80	S(+)
Virginia	2	2.056	17	8.27	2.180	22	10.09	N.S.
Total	5	6.743	36	5.34	5.638	49	8.69	S(+)
ADT = 501-1,000 VPD								
North Carolina	2	6.339	40	6.31	6.474	40	6.18	N.S.
Missouri	1	1.900	15	7.89	1.900	10	5.26	N.S.
Total	3	8.239	55	6.68	8.374	50	5.97	N.S.
ADT = >1,000 VPD								
Missouri	2	10.035	21	2.09	8.399	20	2.38	N.S.
Virginia	1	3.796	20	5.27	4.640	18	3.88	N.S.
Total	3	13.831	41	2.96	13.039	38	2.91	N.S.
Grand total	11	28.813	132	4.58	27.051	137	5.06	N.S.

Note: N.S. = nonsignificant.

[a]Significance at 90 percent confidence level using two-tailed t-test.

TABLE 8 Comparison of Before-After Accident Statistics by ADT for Sites with 8-9 ft Lanes Where Centerline and No-Passing Zone Marking were Added (FHWA data base)

		Before Period			After Period			
State	No. of Sites	Vehicle Miles (millions)	No. of Accidents	Accident Rate	Vehicle Miles (millions)	No. of Accidents	Accident Rate	Significant Difference[a]
ADT = 0-500 VPD								
North Carolina	9	13.347	53	3.97	13.661	50	3.66	N.S.
Virginia	13	13.775	56	4.07	14.220	66	4.64	N.S.
Total	22	27.122	109	4.02	27.881	116	4.16	N.S.
ADT = 501-1,000 VPD								
North Carolina	2	10.089	34	3.37	10.322	60	5.81	S(+)
Virginia	4	5.981	31	5.18	6.402	31	4.84	N.S.
West Virginia	3	4.031	14	3.47	4.059	23	5.67	N.S.
Total	9	20.101	79	3.93	20.783	114	5.49	S(+)
ADT = >1,000 VPD								
Virginia	2	5.020	27	5.38	5.738	31	5.40	N.S.
West Virginia	4	32.290	130	4.03	35.174	118	3.35	N.S.
Total	6	37.310	157	4.21	40.912	149	3.64	N.S.
Grand total	37	84.533	345	4.08	89.576	379	4.23	N.S.

Note: N.S. = nonsignificant.

[a]Significance at 90 percent confidence level using two-tailed t-test.

TABLE 11 Summary of Before-After Accident Statistics for Projects in Missouri Where Dashed Centerlines Only Were Added

Accident Parameters	Before Period			After Period			
	Vehicle Miles (millions)	No. of Accidents	Accident Rate	Vehicle Miles (millions)	No. of Accidents	Accident Rate	Significant Difference[a]
Total accidents	12.426	32	2.58	12.752	40	3.14	No
Injury and fatal accidents	12.426	14	1.13	12.752	19	1.49	No

Note: The number of projects was 9, the number of miles was 58.45, the ADT range was 88-512 vpd, and the lane widths were 10-11 ft.
[a]Significance at 90 percent confidence level using two-tailed t-test.

TABLE 12 Summary of Before-After Statistics by ADT for 20 Projects in Missouri Where No-Passing Zone Markings Were Added to Existing Centerline Markings (10-11 ft lanes)

ADT (vpd)	No. of Projects	No. of Miles	Before Period			After Period			
			Vehicle Miles (millions)	No. of Accidents	Accident Rate	Vehicle Miles (millions)	No. of Accidents	Accident Rate	Significant Difference[a]
501-1,000	7	66.10	44.263	103	2.33	45.949	80	1.74	S(-)
>1,000	13	130.59	139.011	281	2.02	141.279	220	1.56	S(-)
Total	20	196.69	183.374	384	2.09	187.228	300	1.60	S(-)

[a]Significance at 90 percent confidence level using two-tailed t-test.

TABLE 13 Summary of Before-After Statistics by ADT for 33 Projects in Missouri Where No-Passing Zone Markings Were Added to Existing Centerline and Edgeline Markings

ADT (vpd)	No. of Projects	No. of Miles	Before Period			After Period			
			Vehicle Miles (millions)	No. of Accidents	Accident Rate	Vehicle Miles (millions)	No. of Accidents	Accident Rate	Significant Difference[a]
0-500	4	35.59	11.740	36	3.07	14.364	36	2.51	None
501-1,000	17	355.01	192.841	496	2.57	202.557	503	2.48	None
>1,000	12	241.61	244.649	689	2.82	240.415	708	2.94	None
Total	33	632.21	449.230	1,221	2.72	457.336	1,247	2.73	None

[a]Significance at 90 percent confidence level using two-tailed t-test.

TABLE 14 Change in Accident Rates Associated with Center Markings *(3,4)*

ADT (vpd)	Lane Widths					
	8-9 ft	Change (%)	10-11 ft	Change (%)	All Lane Widths	Change (%)
0-500	FHWA Data Base 1[a]	+3	FHWA Data Base 1	+63[c]	FHWA Data Base 1	+15
	FHWA Data Base 2[b]	+15	FHWA Data Base 2	+55[c]	FHWA Data Base 2	+15[c]
	Missouri (dashed centerline only added)	+32				
500-1,000	FHWA Data Base 1	+40[c]	FHWA Data Base 1	−11	FHWA Data Base 1	+19
	FHWA Data Base 2	+47[c]	FHWA Data Base 2	+7	FHWA Data Base 2	+29[c]
			Missouri (no-passing stripe added)	−25[c]		
Greater than 1,000	FHWA Data Base 1	−14	FHWA Data Base 1	−2	FHWA Data Base 1	−10
	FHWA Data Base 2	−5	FHWA Data Base 2	−16	FHWA Data Base 2	−9
			Missouri (no-passing stripe added)	−23[c]		
All ADTs	FHWA Data Base 1	+4	FHWA Data Base 1	+10	1981 FHWA Stewardship Report	+1
	FHWA Data Base 2	+15[c]	FHWA Data Base 2	+1	1982 FHWA Stewardship Report	−1
					FHWA Data Base 1	+5
					FHWA Data Base 2	+13[c]
					Ohio Data Base	−35[c]

[a]FHWA Data Base 1 includes 48 before-after site comparisons between no markings and combined centerline and no-passing zone markings (5 states).
[b]FHWA Data Base 2 includes 87 sites with no markings and 111 sites with both centerline and no-passing zone markings (5 states).
[c]Statistically significant change at 90 percent confidence level.

TABLE 9 Comparison of Accident Rates for Sites with no Markings to Sites with Centerline and No-Passing Zone Markings (FHWA total data base)

State	No Lines				Centerline and No Passing Zone				Significant Difference[a]
	No. of Sites	Vehicle Miles (millions)	No. of Accidents	Accident Rate	No. of Sites	Vehicle Miles (millions)	No. of Accidents	Accident Rate	
ADT = 0-500 VPD/lane width = 8-9 ft									
North Carolina	21	32.758	117	3.57	59	82.133	344	4.19	N.S.
Virginia	13	13.775	56	4.07	13	14.220	66	4.64	N.S.
Total	34	46.533	173	3.72	72	96.353	410	4.26	N.S.
ADT = 501-1,000 VPD/lane width = 8-9 ft									
North Carolina	3	14.930	51	3.42	4	16.405	84	5.12	S(+)
Virginia	4	5.981	31	5.18	5	9.177	44	4.79	N.S.
West Virginia	5	9.122	22	2.41	3	4.059	23	5.67	S(+)
Total	12	30.033	104	3.46	12	29.641	151	5.09	S(+)
ADT = > 1,000 VPD/lane width = 8-9 ft									
Virginia	2	5.020	27	5.38	2	5.738	31	5.40	N.S.
West Virginia	6	42.175	154	3.65	4	35.174	118	3.35	N.S.
Total	8	47.195	181	3.84	6	40.912	149	3.64	N.S.
Grand total	54	123.761	458	3.70	90	166.906	710	4.25	S(+)

Note: N.S. = nonsignificant.

[a]Significance at 90 percent confidence level using two-tailed t-test.

TABLE 10 Comparison of Accident Rates for Sites with no Markings to Sites with Centerline and No-Passing Zone Markings (FHWA data base)

State	No Lines				Centerline and No Passing Zone				Significant Difference[a]
	No. of Sites	Vehicle Miles (millions)	No. of Accidents	Accident Rate	No. of Sites	Vehicle Miles (millions)	No. of Accidents	Accident Rate	
ADT: 0-500 VPD/lane width = 10-11 ft									
Missouri	8	11.304	46	4.40	2	4.186	13	3.11	N.S.
Montana	3	4.963	16	3.22	2	2.449	24	9.80	S(+)
Virginia	2	2.056	17	8.27	2	2.180	22	10.09	N.S.
Total	13	18.323	79	4.31	6	8.815	59	6.69	S(+)
ADT: 501-1,000 VPD/lane width = 10-11 ft									
Missouri	11	31.129	104	3.34	2	4.180	15	3.59	N.S.
North Carolina	2	6.339	40	6.31	4	14.526	62	4.27	S(-)
Total	13	37.468	144	3.84	6	18.706	77	4.12	N.S.
ADT = > 1,000 VPD/lane width = 10-11 ft									
Missouri	6	43.703	116	2.65	2	8.399	20	2.38	N.S.
Virginia	1	3.796	20	5.27	7	27.751	67	2.41	S(-)
Total	7	47.499	136	2.86	9	36.150	87	2.41	N.S.
Grand total	33	103.290	359	3.48	21	63.671	223	3.50	N.S.

Note: N.S. = nonsignificant.

[a]Significance at 90 percent confidence level using two-tailed t-test.

These tables also show a trend toward rate reduction with higher ADTs.

EFFECTIVENESS OF ADDING ONLY DASHED CENTERLINE MARKINGS TO UNMARKED HIGHWAYS

The study indicated that Missouri was the only state that made extensive use of a dashed centerline without a nonpassing stripe. The practice is to use this treatment on unnumbered state highways with less than 1,000 vpd. These highways are basically local rural access roads. The data in Table 11 give an evaluation of nine projects where dashed centerlines only were added to previously unmarked highways with between 88 and 512 vpd and a lane width of between 10 and 11 ft. This analysis shows a 22 percent nonsignificant increase in accident rates.

EFFECTIVENESS OF ADDING NO-PASSING ZONE MARKINGS

The data further indicated that Missouri also provided for evaluating the effectiveness of adding no-passing stripes to highways previously marked with dashed centerlines only. The data in Table 12 give an evaluation of 20 projects where no-passing zone markings were added to highways with lane widths of between 10 and 11 ft previously marked with dashed centerline only. This evaluation shows significant decreases in accident rates for both ADT levels of between 501 and 1,000 vpd and greater than 1,000 vpd.

The data in Table 13 give an evaluation of 33 projects where no-passing zone markings were added to highways previously marked with dashed centerline

only and edgelines. This evaluation shows no significant differences in accident rates for any ADT category.

SUMMARY OF ACCIDENT COMPARISONS

Several sources of data were gathered to analyze the potential safety effectiveness of the application of centerline and no-passing zone markings. Most of the data represented before and after comparisons made as a part of the PMDP. The data in Table 14 give a summary of the sources, accident reduction effectiveness, and statistical significance of comparisons. The results of Table 14 are somewhat conflicting but do indicate that:

1. Widespread application of center pavement markings to all paved roads with no existing markings is not likely to produce accident reduction benefits;
2. Center markings applied to roads with 500 or less vpd appear to produce increased accident rates;
3. Center markings applied to roads with less than 10-ft lane widths and fewer than 1,000 vpd appear to produce increased accident rates; and
4. Accident reduction benefits may be generally associated with wider roads and higher ADTs.

CONCLUSIONS

The nationwide application of center markings on previously unmarked two-lane rural roads under the federal PMDP does not appear to have produced any reduction in accident rates. In fact, the before-after results for hundreds of center marking projects in 15 states indicate a significant increase in injury accident rates (3,4).

Despite this seemingly negative result, a more detailed analysis of available data indicates potential accident benefits for wider roads that carry higher traffic volumes. This result was evident both for adding centerline and no-passing zone markings to previously unmarked roads and for adding no-passing zone marking to roads previously marked with only a dashed centerline.

Although the data were not sufficient for determining specific road width and ADT warrants based on a precise breakpoint of cost-effectiveness, they do seem to indicate lower boundaries for these warrants based on omitting center markings where they appear to produce significant increases in accident rates. By using this basis, the following tentative warrants seem reasonable for the application of both dashed centerline and no-passing zone markings:

Road Width (ft)	Minimum ADT (vpd)
Less than 16	Not Applicable
16-18	1,000
20 or greater	500

This concept of road width and minimum ADT warrants is generally consistent with current state department of transportation practice in those states that have high portions of low-volume road mileage (6). The practice of not marking low-volume rural roads is also prevalent among local rural jurisdictions. Perhaps the lack of markings on these roads, which tend to have lower design standards, provides the driver a greater ability to distinguish the need for a more cautious driving behavior than is required on higher-volume roads with better design standards.

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