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The Relationship Between Access Density and Accident Rates: Comparisons of *NCHRP Report 420* and Minnesota Data

This digest summarizes findings of NCHRP Project 3-52A, "Impacts of Access-Management Techniques." This digest was prepared by Mr. Jerome Gluck of Urbitran Associates, Inc. and by Mr. Herbert S. Levinson, Transportation Consultant. The objective of this project was to further the work of Project 3-52 by recommending text for the AASHTO Policy on Geometric Design of Highways and Streets and collecting and analyzing additional data on the relationship between access density and accident rates.

INTRODUCTION

NCHRP Report 420, "Impacts of Access Management Techniques," presents relationships between access density and accident rates. This digest uses additional data from Minnesota to confirm these relationships. Additional information on the procedures for estimating the effects of access spacing and other access-related techniques is presented in *NCHRP Report 420.*

Research linking access density to safety spans many decades. *NCHRP Report 420* contains an extensive analysis of many studies relating access spacing to accidents. These studies consistently found that an increase in the number of access points translated into higher accident rates. Although the specific relationships vary, reflecting differences in road geometry, operating speeds, traffic volumes, and accident-reporting thresholds, in every case more access results in more accidents.

Extensive accident analysis was performed in NCHRP Project 3-52 of accident information obtained for Michigan, Illinois, Wisconsin, Delaware, and New Jersey. The data analyzed contained nearly 37,500 accidents and included 152 urban/suburban and 89 rural road segments. Accident-reporting thresholds were generally $500.

Accident rates were derived for total, unsignalized, and signalized access densities for three types of median treatments: undivided medians, non-traversable medians, and two-way left-turn lanes (TWLTLs). Accident indices for urban/suburban roads were computed using 10 access points per mile as a base for each access density increment, and these indices were compared with those obtained in the literature review.

The current research effort analyzed access and accident information for Minnesota. Its goal was to identify whether the safety impacts of access density and median treatment set forth in *NCHRP Report 420* are consistent with the patterns found in Minnesota.

The 1994 and 1995 accident and traffic volume information was obtained from the Highway Safety Information System of the Federal Highway Administration (FHWA). Data were classified into the same access density strata as were used in *NCHRP Report 420.* The database that was used contained 700 urban segments and about 1,700 rural segments, with a total of approximately 15,000 accidents. The accident-reporting threshold in Minnesota is $1,000.

Accident indices were derived for Minnesota data. These indices were then compared with those developed in *NCHRP Report 420.*

CONTENTS

PROBLEM STATEMENT

Streets and highways constitute a valuable resource and a major public investment. It is essential to operate them safely and efficiently by managing the access to and from abutting properties. Owners have a right to reasonable access to the general system of streets and highways. Roadway users have the right to freedom of movement, safety, and efficient expenditure of public funds. The need to balance these competing rights is especially acute where significant changes in land development have occurred or are envisioned to occur. The safe and efficient operation of the highway system calls for effectively managing the access to adjacent developments.

Access management provides access to land development while simultaneously preserving the flow of traffic on the surrounding road network in terms of safety, capacity, and speed. Access management benefits the transportation system by preserving capacity, maintaining mobility, and improving safety. These benefits have been recognized at all levels of government. Four states—Colorado, Florida, New Jersey, and Oregon—have implemented comprehensive statewide access codes. Some states are reviewing their statewide practices and/or developing access codes. Other states are upgrading their access design criteria. Several counties and cities have patterned their codes on the statewide codes. A growing number of cities, counties, and planning regions are managing property access by closing, consolidating, or improving driveways.

Transportation agencies and private developers continue to seek better methods to evaluate the benefits and effects of various access management techniques. Three reasons, in particular, underscore the need for better methods of application and analysis of access management techniques:

- The emergence of comprehensive access management codes provides a context for access management decisions, controls, and the application of specific techniques.
- New analytical tools and techniques provide updated parameters and procedures for assessing impacts.
- Travel time, safety, and economic benefits generally rely on information collected in past decades. A new database that reflects recent research and conditions as closely as possible is needed.

OBJECTIVE AND APPROACH

The research objective of NCHRP Project 3-52, "Impacts of Access-Management Techniques," as defined in the project statement, was "to develop methods of predicting and analyzing the traffic-operation and safety impacts of selected access management techniques for different land use, roadway variables, and traffic volumes. The methods to be developed are for use by state departments of transportation, city and county traffic departments, transportation-planning agencies, and private developers."

The research involved a two-phase approach to achieve this objective and to produce practical guidelines for the application, analysis, and selection of various access management techniques. In the first phase, researchers identified the various techniques available; showed how they can be classified in terms of functional objectives, roadway elements, and likely effects; and suggested priority techniques for further analysis. Likely effects were extracted on the basis of a literature review, the research team's experience, and selected agency review, and the need for further data collection was identified. First-phase efforts concluded with the design of data collection plans that addressed the data voids for the more important techniques.

The second phase involved the compilation, collection, and analysis of additional data from both primary and secondary sources. Methods for estimating the safety, operations, and economic effects associated with the more important techniques were developed. *NCHRP Report 420* was prepared to help establish procedures for an administering agency to use in managing access. This research results digest complements *NCHRP Report 420* by providing additional analyses on the relationship between access density and accident rates based on the Minnesota databases.

BACKGROUND

Minnesota Department of Transportation roadways, intersection, driveway, and accident files were obtained from the Highway Safety Information System of the FHWA, along with detailed traffic flow maps for 1994 and 1995. The 1994 and 1995 files were then combined to create a single comprehensive database. Freeways and expressways were removed from these files using the Access Control and Functional Class variables. The resulting database encompassed 24,261 segments, 10,510 miles and 37,780 accidents.

The database was further screened to remove anomalous data points. The data-screening process is summarized in Figure 1. (Appendix A, which is not published here but is available for loan or purchase upon request from NCHRP, provides the details of this process.)

1. Segments with inconsistent mileage information (i.e., segment length did not equal the difference between beginning and ending mileposts); average daily traffic less than 3,750 vehicles per day; and/or anomalous traffic volumes were excluded. This left 10,392 segments, 1,659 miles and 21,591 accidents.
2. Segments less than 0.31 mile long were summed where geographically contiguous and identical in the number of lanes and median treatment. Those that could not be summed up were excluded. This step left 747 urban segments with 10,746 accidents and 1,699 rural segments with 4,439 accidents.

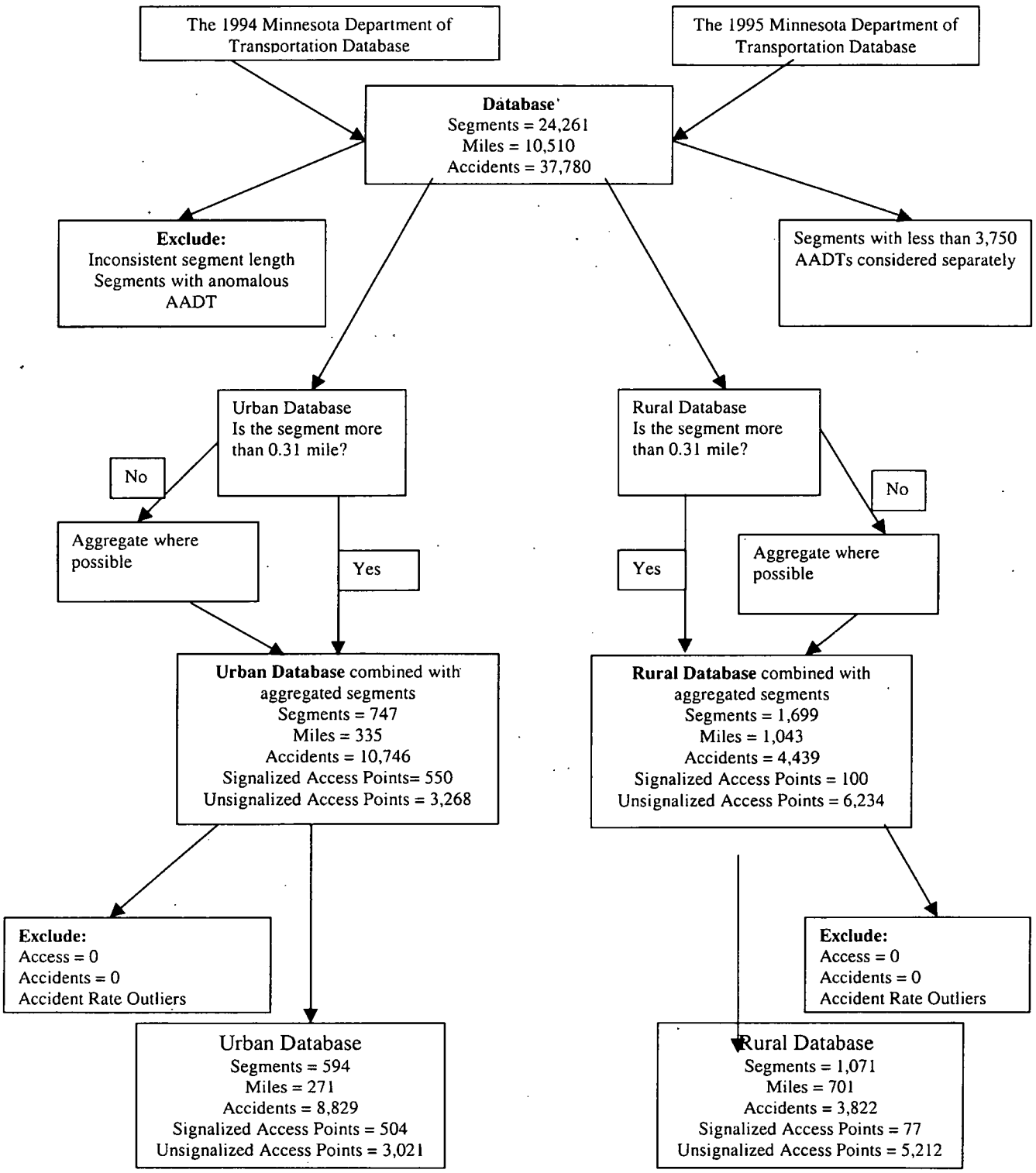

Figure 1. Data analysis sequence.

3. The few segments with zero accidents and/or zero access points were removed.
4. Accident rate outliers were identified (using statistical testing) and removed from the database.

The resulting urban database contained 594 road segments along 271 miles of road with 8,829 accidents. The rural database contained 1,071 segments along 701 miles of road with 3,822 accidents.

NCHRP Report 420 found that accident rates (accidents per million vehicle miles traveled) reflect access density, area type (urban/rural), and median type. Accordingly, similar variables and classification strata were used to analyze the Minnesota data.

Urban/suburban road segments were grouped in increments of 20 access points per mile and in signalized density increments of 2 signalized access points per mile. The resulting access density strata and the number of segments in each stratum are shown in Table 1.

Rural road segments were grouped in increments of 15 access points per mile. The resulting access density strata and the number of segments in each stratum are shown in Table 2.

Accident rates were calculated for rural and urban segments of each density class by averaging the rates of that class. Outlier tests were used to identify accident rates that did not appear consistent with the rest of the data or the pertinent roadway characteristics. These outliers were removed from the database.

A total of 18 segments with 642 accidents were screened out from the urban database, and 38 segments with 613 accidents were removed from the rural database.

RESULTS

The following sections summarize the results of the Minnesota accident rate analysis for urban/suburban and rural areas. The accompanying tables give the number of cases, means, and coefficients of variation for each cell analyzed.

TABLE 1 Access density statistics for urban segments

Total Access Density	**≤20**	**20.01 to 40**	**40.01 to 60**
Number of Segments	449	135	10
Percent of Segments	75.34	22.99	1.68
Mean Access Points	8.25	27.64	43.82
Median Access Points	6.88	26.32	42.05
Signalized Access Density	**≤2**	**2.01 to 4**	**4.01 to 6**	**>6.01**
Number of Segments	375	59	110	50
Percent of Segments	62.92	9.90	18.79	8.49
Mean Access Points	0.02	2.67	4.64	9.23
Median Access Points	0.00	2.53	4.51	8.50
Unsignalized Access Density	**≤20**	**20.01 to 40**	**40.01 to 60**
Number of Segments	480	108	6
Percent of Segments	80.54	18.46	1.00
Mean Access Points	7.42	26.91	45.38
Median Access Points	6.10	25.90	44.64

TABLE 2 Access density statistics for rural segments

Total Access Density	**≤15**	**15.01 to 30**	**>30.01**
Number of Segments	876	157	38
Percent of Segments	81.97	14.43	3.61
Mean Access Points	5.64	21.47	34.86
Median Access Points	4.75	21.28	34.32

TABLE 3 Accident rates by total access density and median treatment for urban/suburban areas

Access Density	Statistics	Median Treatment			
		Undivided	TWLTL	Non-Traversable	*Total*
<=20	Cases	214	7	228	*449*
	Mean	2.67	2.66	2.23	*2.45*
	C.V.	0.86	0.97	0.82	*.85*
20.1 to 40	Cases	106	1	28	*135*
	Mean	5.33	9.8	4.84	*5.26*
	C.V.	0.85	NA	0.58	*.81*
40.01 to 60	Cases	6	NA	4	*10*
	Mean	6.9	NA	5.86	*6.47*
	C.V.	0.63	NA	0.4	*.54*
Total	Cases	*326*	*8*	*260*	
	Mean	*3.61*	*3.56*	*2.57*	
	C.V.	*.96*	*.98*	*.84*	

Notes:
Accident Rates = Accidents per Million Vehicle Miles
C.V. = Coefficient of Variation
NA = Not Available
TWLTL = Two-way left-turn lane

Urban/Suburban Areas

Accident rates by the total access density and median type are presented in Table 3. The small number of segments in the TWLTL category reflects the fact that there are very few such segments in Minnesota. (The analysis assumed that the 3-, 5-, and 7-lane road segments had TWLTLs.)

This table shows an increase in the accident rate for each type of median treatment as access density increases. Overall, the accident rates for densities of 40 to 60 access points per mile are more than 2.5 times the accident rates for densities of up to 20 access points per mile. This relative increase in the accident rate is similar to that reported in *NCHRP Report 420.*

Table 3 also shows the accident rate reductions associated with the three types of median treatments. Roadways with non-traversable medians have about 70 percent the number of accidents of that on undivided roadways. *NCHRP Report 420* reported a 60-percent value.

Table 4 shows the effects of signalized access density on the accident rates for the three median types. There is a sharp increase in the accident rates as traffic signals become more numerous (i.e., signalized access density increases). As signalized density increases from less than 2 to over 6 signals per mile, the accident rate more than triples. *NCHRP Report 420* analysis found an increase of 260 percent (the one inconsistency is for the TWLTL with a signal density of 4 to 6 signals per mile category, which contains only one record).

Accident rates were also computed for various cross classifications of signalized and unsignalized access density. The results are shown in Table 5. The accident rates increase as signalized and unsignalized density increase. The patterns for the Minnesota data are similar to those reported in *NCHRP Report 420,* except that the rates are typically lower. This may be the result of the higher Minnesota accident-reporting threshold.

Rural Areas

A similar analysis was performed for Minnesota road segments in rural areas. Accident rates were stratified by total access density and type of median treatment. For rural areas, access density strata were defined (as in *NCHRP Report 420*) in terms of 0 to 15, 15.01 to 30, and greater than 30 access points per mile. Signalized access density was not considered separately because of the small number of signalized access points along the rural segments. As in *NCHRP Report 420,* the TWLTL classification was included in the review, even though it represents a very small number of road segments and does not offer any statistically valid results.

The general accident rate patterns found are similar to those reported in *NCHRP Report 420.* Overall, accident rates on roadways with greater than 30 access points per mile are three times greater than the accident rates on road segments with fewer than 15 access points per mile. Highways with non-traversable medians show consistently lower accident rates than undivided roadways. Table 6 reports the accident

TABLE 4 Accident rates by signalized density for urban/suburban areas

Access Density	Statistics	Median Treatment			
		Undivided	TWLTL	Non-Traversable	*Total*
<=2	Cases	240	5	129	*375*
	Mean	2.48	1.99	1.66	*2.19*
	C.V.	0.81	1.41	1.05	*0.90*
2.01 to 4	Cases	29	2	28	*59*
	Mean	5.06	6.81	2.45	*3.88*
	C.V.	0.71	0.63	0.69	*0.81*
4.01 to 6	Cases	35	1	74	*110*
	Mean	6.3	4.9	3.24	*4.35*
	C.V.	0.63	NA	0.52	*0.78*
>6	Cases	22	NA	28	*50*
	Mean	9.76	NA	5.12	*7.16*
	C.V.	0.55	NA	0.53	*0.65*
Total	Cases	*326*	*8*	*260*	
	Mean	*3.61*	*3.56*	*2.57*	
	C.V.	*0.96*	*0.98*	*0.84*	

Notes:
Accident Rates = Accidents per Million Vehicle Miles
C.V.= Coefficient of Variation
NA = Not Available
TWLTL = Two-way left-turn lane

TABLE 5 Accident rates and signalized/unsignalized access for urban/suburban areas

Signalized Access Density	Statistics	Unsignalized Access Density			
		<=20	20 to 40	40 to 60	*Total*
<=2	Cases	305	65	5	*375*
	Mean	2.01	2.87	4.34	*2.19*
	C.V.	0.94	0.72	0.57	*0.90*
2.01 to 4	Cases	43	15	1	*59*
	Mean	2.89	6.43	8.16	*3.88*
	C.V.	0.60	0.71	NA	*0.81*
4.01 to 6	Cases	98	12	NA	*110*
	Mean	3.86	7.30	NA	*4.00*
	C.V.	0.67	0.57	NA	*0.78*
>6	Cases	34	16	NA	*50*
	Mean	7.01	7.48	NA	*7.16*
	C.V.	0.67	0.64	NA	*0.65*
Total	Cases	*480*	*108*	*6*	
	Mean	*2.82*	*4.54*	*4.98*	
	C.V.	0.96	0.84	0.55	

Notes:
Accident Rates = Accidents per Million Vehicle Miles
C.V.= Coefficient of Variation
NA = Not Available
TWLTL = Two-way left-turn lane

TABLE 6 Accident rates by access density and median treatment for rural areas

Access Density	Statistics	Median Treatment			
		Undivided	TWLTL	Non-Traversable	*Total*
<=15	Cases	601	4	271	*876*
	Mean	1.10	1.57	0.98	*1.06*
	C.V.	0.76	0.26	0.79	*0.77*
15.01 to 30	Cases	150	NA	7	*157*
	Mean	2.87	NA	1.76	*2.82*
	C.V.	0.83	NA	0.51	*0.83*
>30	Cases	38	NA	NA	*38*
	Mean	3.54	NA	NA	*3.54*
	C.V.	0.65	NA	NA	*0.64*
Total	Cases	*789*	*4*	*278*	
	Mean	*1.55*	*1.57*	*1.00*	
	C.V.	*1.02*	*0.26*	*0.79*	

Notes:
Accident Rates = Accidents per Million Vehicle Miles
C.V.= Coefficient of Variation
NA = Not Available
TWLTL = Two-way left-turn lane

rates by total access density and median treatment for rural Minnesota roadways.

COMPARISONS

The NCHRP and Minnesota accident rates are compared graphically in Figures 2, 3, and 4.

Figures 2 and 3 present accident rates by median treatment and access density (both directions) for urban/suburban and rural roadways, respectively. Figure 4 presents accident rates by signalized and unsignalized access density for urban/suburban segments. Minnesota curves are superimposed on those presented in *NCHRP Report 420.* In both cases, rates are shown for the midpoints of unsignalized access spacing groups.

The urban/suburban accident rate patterns are similar between the Minnesota data and *NCHRP Report 420* analysis.

The rural accident rate patterns for both sets of data are generally the same. Both NCHRP and Minnesota data exhibit a gradual increase in the accident rates as access density increases. The Minnesota rates for highways with non-traversable medians are higher than those reported in *NCHRP Report 420,* but the rates for undivided highways are lower than those in *NCHRP Report 420.*

ACCIDENT RATE INDICES

Accident rate indices set forth in *NCHRP Report 420* (page 56) were compared with those obtained from the Minnesota data analysis. The indices were derived using the ratios of accident rates at each access density classification midpoint (i.e., 20, 30, 40, and 50 access points per mile) and the rate at 10 access points per mile. Computation of the indices eliminates the differences between the Minnesota data and *NCHRP Report 420* that were due to different accident-reporting thresholds.

The indices are compared in Table 7 for urban/suburban arterials. They indicate the generalized effects of access spacing on safety. The indices show the relative increases in accident rates as total access density increases. They may be used to project the safety impacts resulting from adding access points to a given roadway.

Table 7 shows that the indices derived from the Minnesota data are comparable to those reported in *NCHRP Report 420.*

As indicated in *NCHRP Report 420,* many specific circumstances influence accident rates when compared from state to state. States may underestimate accidents where the number or proportion of nonreportable accidents is high, especially where traffic flow is heavy. Driveway and crossing volumes may vary, limiting the utility of considering arterial VMT alone. Reporting thresholds also vary by state.

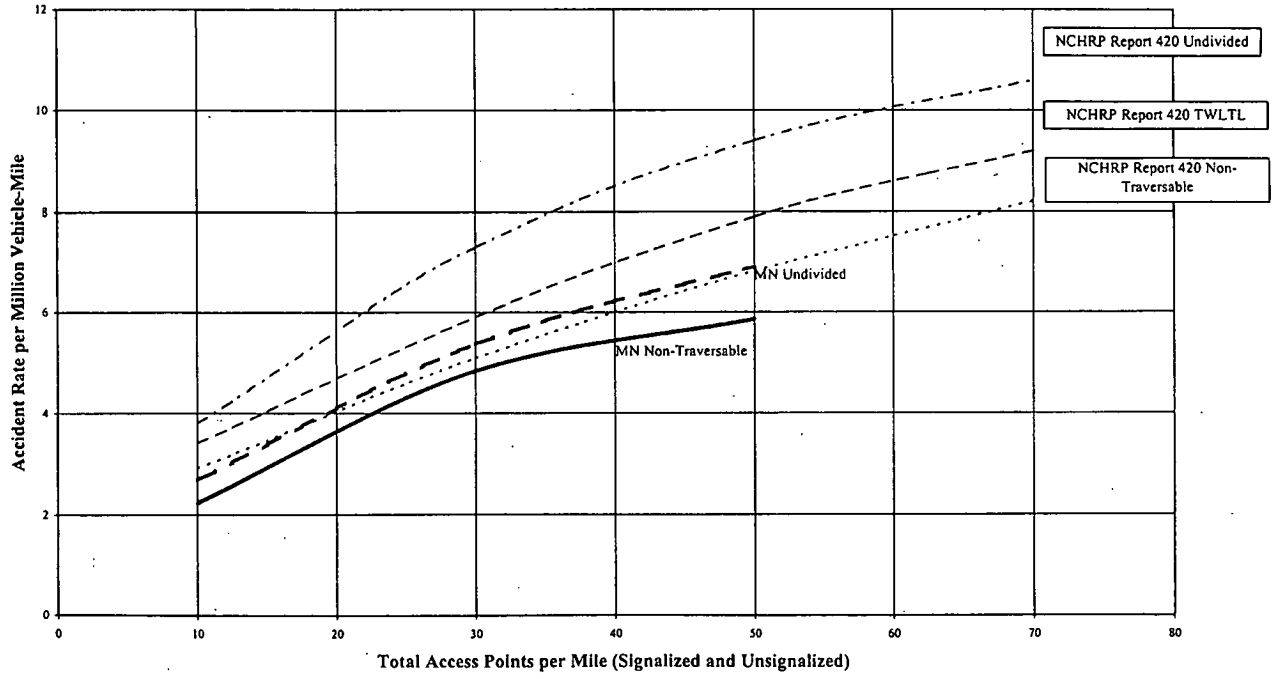

Figure 2. Comparison of accident rates by access density and median type for urban/suburban areas.

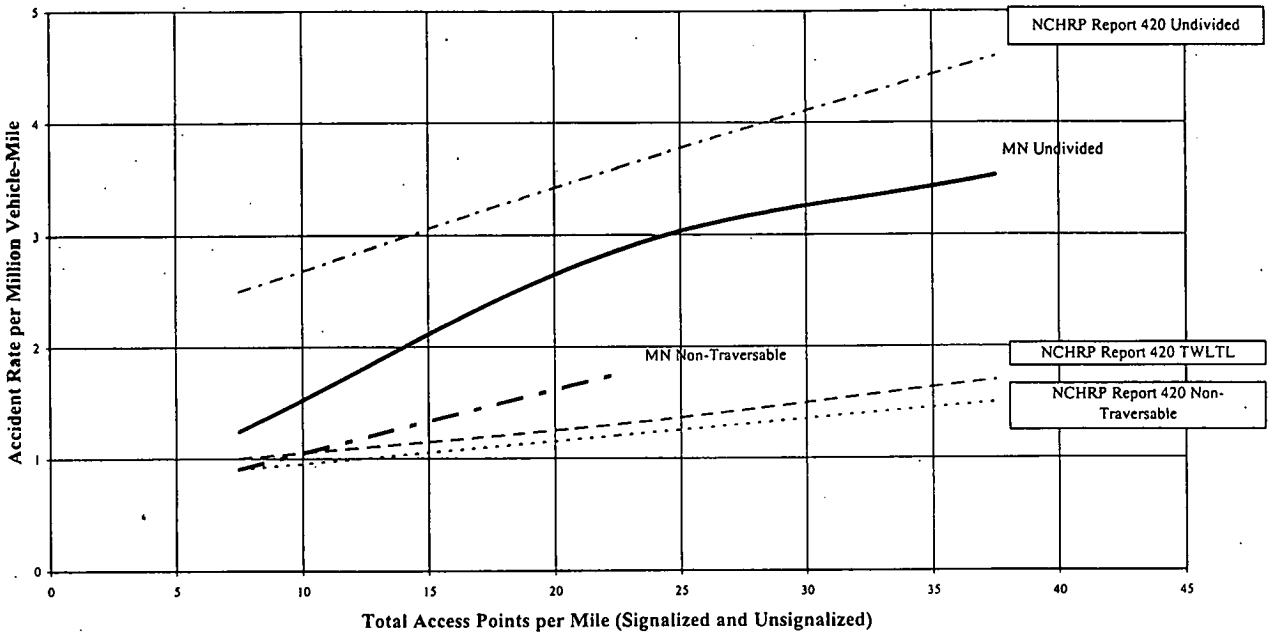

Figure 3. Comparison of accident rates by access density and median type for rural areas.

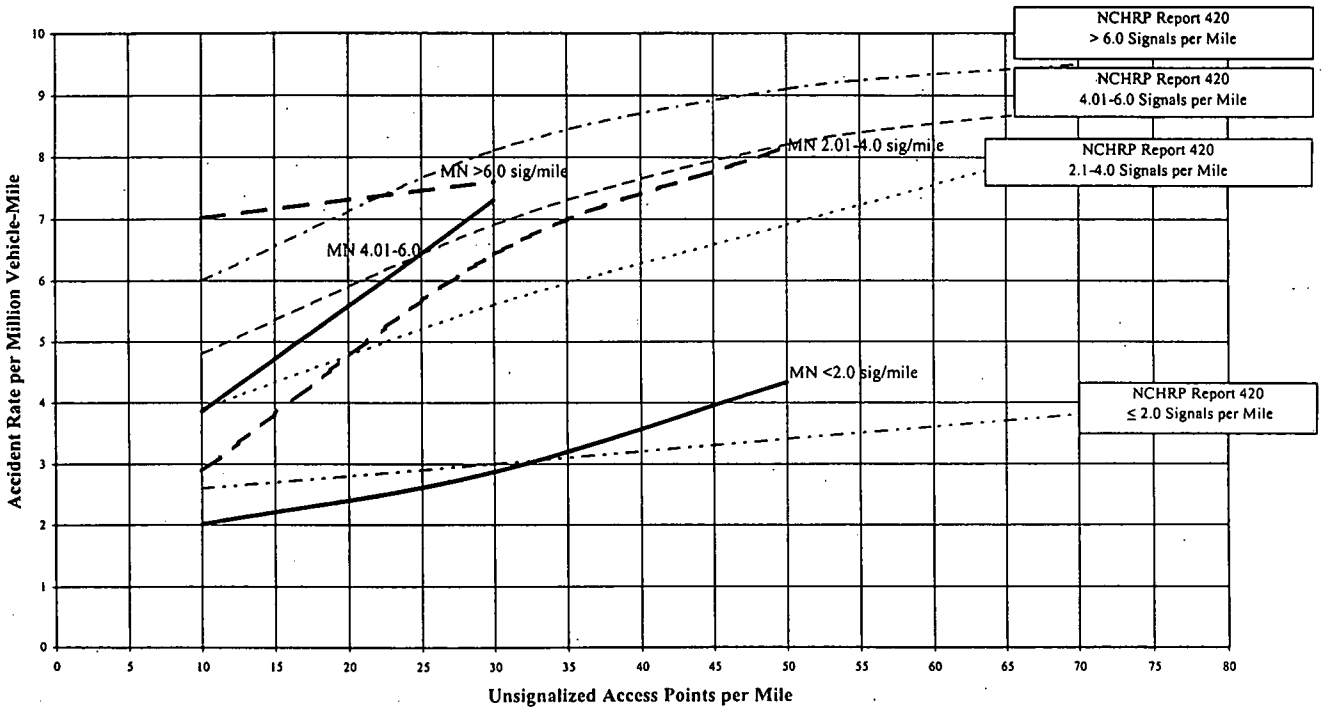

Figure 4. Comparison of accident rates by signalized/unsignalized access density for urban/suburban areas.

TABLE 7 Comparison of safety indices

Access Points Per Mile	Safety Analysis[1]	Literature Synthesis[1]	Minnesota Data	Suggested Value[1]
10	1.0	1.0	1.0	1.0
20	1.4	1.3	1.6	1.4
30	1.8	1.7	2.2	1.8
40	2.1	2.1	2.4	2.1
50	2.3	2.8	2.6	2.5

[1] Source: *NCHRP Report 420,* page 56

The accident rate index, nevertheless, can be applied to estimate the likely change in rates as access points are added to or removed from a roadway. The expected accident rate is equal to the observed rate times the change in the index value.

REFERENCE

1. Gluck J., H.S. Levinson, and V. Stover. *NCHRP Report 420,* "Impacts of Access Management Techniques." Transportation Research Board, National Research Council, Washington D.C., 1999.

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