Relationship of Lane Width to Safety for Urban and Suburban Arterials

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by
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ABSTRACT: This research investigates the relationship between lane width and safety for roadway segments and intersection approaches on urban and suburban arterials. The research found no general indication that the use of lanes narrower than 3.6 m (12 ft) on urban and suburban arterials increases crash frequencies. This finding suggests that geometric design policies should provide substantial flexibility for use of lane widths narrower than 3.6 m (12 ft). Inconsistent results were found which suggested increased crash frequencies with narrower lanes in three specific design situations. Narrower lanes should be used cautiously in these three specific situations unless local experience indicates otherwise.

INTRODUCTION

This research addresses the relationship of lane width to safety for urban and suburban arterials. A cross-sectional safety analysis approach was used because suitable sites to conduct a before-after observational study were not available. Lane width for both midblock segments and intersection approaches has been considered. A full report of the results of this research has been prepared by Potts et al. (*1*).

CURRENT STATE OF KNOWLEDGE ON SAFETY EFFECTS OF LANE WIDTHS

The "conventional wisdom" of most highway engineers is that use of narrower lanes in the design of a roadway will result in more crashes if other design characteristics of the roadway remain unchanged. This has been demonstrated for lane widths on rural two-lane highways (2), but there is no definitive research on the safety effect of lane widths for urban and suburban arterials. If narrower lanes can be used on urban and suburban arterials without affecting safety negatively, there may be many other benefits to highway agencies and highway users. The use of narrower through-traffic lanes may have advantages in some situations on arterials because this may reduce pedestrian crossing distances and may provide space for additional through lanes, auxiliary lanes, bicycle lanes, buffer areas between travel lanes and sidewalks, and placement of roadside hardware. However, the use of narrower lanes has been accompanied by concerns that reducing lane widths could increase crash frequencies. Highway agencies would be reluctant to look for benefits from using narrower lanes if crashes would be increased, but there are no definitive studies in the literature that address the relationship between lane width and safety for midblock segments of urban and suburban arterials.

A number of past studies have been conducted to determine the traffic safety effects of lane width, but the results of these studies are varied. Despite the extensive research that has been conducted on the effect of lane width on motor vehicle safety, it is difficult to draw any definite conclusions about the relationship. Hauer (*3*) developed six statistical models to predict the nonintersection accident frequency of urban four-lane undivided roads. Separate models were developed for "off-the-road" and "on-the-road" accidents. Hauer concluded that for "off-the-road" accidents, if accident frequency is influenced by lane width, it is not discernable. For "on-the-road" accidents, lane width was found to be associated with property-damage only (PDO) accidents, but not injury accidents. In the PDO model, Hauer notes that wider lanes are associated with higher accident frequency frequencies (**not** lower accident frequencies.) However, Hauer notes that the relationship is weak, and lane width is only included in the model because of the traditional interest in this variable.

Research by Strathman (*4*) on the design attributes and safety on Oregon State highways found no relationship between lane width and accident frequency for urban nonfreeways.

Hadi (*5*) developed negative binomial regression models to estimate the safety of various cross-sectional elements and did find significant relationships between lane width and accidents for undivided highways. Hadi found that increasing lane widths up to 3.7 m (12 ft) and 4.0 m (13 ft) would be expected to decrease accident rates for urban two-lane roadways and urban four-lane undivided roadways, respectively.

While many countermeasures have been identified to reduce crossing distance at intersections for pedestrians, no studies have documented the quantitative effect of lane width on pedestrian or bicycle safety.

CURRENT GEOMETRIC DESIGN POLICIES FOR LANE WIDTH ON URBAN AND SUBURBAN ARTERIALS

Highway design policies for arterial roadways indicate a preference for the use of 3.6-m (12-ft) lane widths, but also indicate flexibility for use of narrower lanes where 3.6-m (12-ft) lanes are infeasible or impractical (*6*).

The geometric design practices related to lane width must consider the needs of motor vehicle, pedestrian, and bicycle traffic. The AASHTO *Policy on Geometric Design of Highways and Streets* (*6*), commonly known as the *Green Book*, offers guidelines on the selection of appropriate lane widths on urban and suburban arterials considering primarily the needs of motor vehicle traffic. In Chapter 7 of the *Green Book*, lane widths from 3.0 to 3.6 m (10 to 12 ft) are addressed along with specific circumstances for which each width should be considered.

Despite the flexibility provided by geometric design policies and the lack of definitive safety studies, there has always existed a “conventional wisdom” that narrower lanes result in higher crash frequencies. The purpose of this research is to investigate if this “conventional wisdom” is correct, determine whether and how lane width affects safety, and identify situations in which design flexibility to use narrower lanes should or should not be utilized.

SAFETY EVALUATION OF LANE WIDTHS ON ARTERIAL MIDBLOCK SEGMENTS

Available Data Base

Ongoing research in NCHRP Project 17-26, *Methodology to Predict the Safety Performance of Urban and Suburban Arterials,* has developed a database that was used in this research to examine the effects of roadway features, including lane width, on safety for arterials. The objective of NCHRP Project 17-26 is to develop a prediction methodology for urban and suburban arterials for application in the forthcoming *Highway Safety Manual*. This database is also suitable for investigation of the relationship between lane width and safety and has been used for that purpose in the current research (*7*).

The database includes site characteristics, traffic volume, and crash data for arterial roadway segments in Minnesota and Michigan. The roadway segments in Minnesota are located primarily in the Minneapolis-St. Paul metropolitan area and include roadways in both urban and suburban communities. The roadway segments in Michigan are located in Oakland County in the northern portion of the Detroit metropolitan area. Oakland County includes some urban communities, but most of the area would be considered suburban. The database for both areas includes a mixture of arterials under state and local jurisdiction.

The available data include five arterial roadway types:

- two-lane undivided arterials (2U)
- three-lane arterials including a center TWLTL (3T)
- four-lane undivided arterials (4U)
- four-lane divided arterials (4D)
- five-lane arterials including a center TWLTL (5T)

Table 1 presents a summary of the number of sites for which site characteristics including lane width, traffic volume, and crash data are available in each state. Each site consists of one block (i.e., the arterial roadway from one public road intersection to the next). The blocks range from 0.06 to 2.28 km (0.04 to 1.42 mi) with an average block length of 0.21 km (0.13 mi). Table 2 shows comparable data for the total lengths of sites in each table. The database includes 408 mi of urban and suburban arterials (153 mi in Minnesota and 255 mi in Michigan).

TABLE 1. Number of roadway segment analysis sites by roadway type and lane width

Roadway type	Number of sites by lane width (ft)					
	9	10	11	12	13+	Total
MINNESOTA						
2U	2	20	20	162	176	380
3T	–	16	5	73	35	129
4U	19	147	121	91	62	440
4D	–	2	44	61	71	178
5T	–	–	8	18	–	26
Subtotal	21	185	198	405	344	1,153
MICHIGAN						
2U	61	82	229	148	70	590
3T	31	25	12	32	15	115
4U	104	181	157	29	–	471
4D	12	10	69	33	16	140
5T	–	17	357	114	74	562
Subtotal	208	315	824	356	175	1,878
TOTAL	229	500	1,022	76	519	3,031

TABLE 2. Total length of roadway segment analysis sites by roadway type and lane width

Roadway type	Total length of sites (mi) by lane width (ft)					
	9	10	11	12	13+	Total
MINNESOTA						
2U	0.19	2.86	3.34	21.02	24.88	52.29
3T	–	1.27	0.65	11.96	4.14	18.02
4U	–	0.50	5.79	11.29	13.81	31.39
4D	1.43	13.74	14.15	12.77	5.40	47.49
5T	–	–	1.57	2.71	–	4.28
Subtotal	1.62	18.37	25.50	59.75	48.23	153.47
MICHIGAN						
2U	7.50	11.45	33.90	23.81	11.40	88.06
3T	4.11	2.52	1.80	5.36	1.96	15.48
4U	7.76	14.28	14.17	4.07	–	40.28
4D	0.78	9.59	12.01	4.42	2.83	29.63
5T	–	1.16	50.78	19.30	10.27	81.51
Subtotal	20.15	39.00	112.66	55.96	26.46	254.96
TOTAL	21.77	57.37	138.16	116.71	74.69	408.43

The lane widths at these sites were measured in the field. The lane width shown in the table represents the average lane width across all through travel lanes. Sites for which measured lane widths were not available have been omitted from Tables 1 and 2 and from the subsequent analyses. The lane width categories shown in the table are defined as follows:

Lane width category	Range of lane widths (ft)
9	9.5 or less
10	9.5 – 10.5
11	10.5 – 11.5
12	11.5 – 12.5
13+	12.5 or more

Crash data were obtained for all of the sites shown in Table 1 for a five-year period: 1998 to 2002 in Minnesota and 1999 to 2003 in Michigan. The crash data included 4,786 crashes in Minnesota and 17,037 crashes in Michigan. The analysis performed in this study included all multiple- and single-vehicle accidents except pedestrian and bicycle collisions. These were omitted because they are being addressed in separate analyses in NCHRP Project 17-26.

Analysis Approach

The best method to determine the effect of a roadway geometric feature on safety is through a well designed before-after evaluation. While the use of a before-after evaluation would be the preferred approach to determining the effect of lane width on safety, a before-after evaluation was not feasible in this study because highway agencies seldom change the lane width of a roadway without making other changes that would confound the results of any before-after evaluation conducted. Since the before-after evaluation approach was not feasible, a cross-sectional analysis approach was used to investigate the relationship between lane width and safety.

Two approaches to cross-sectional analysis to examine the effect of lane width have been applied in this research. Each approach was applied separately to data from each state and each roadway type. In the first approach, only three variables were considered: average daily traffic (ADT) volume, roadway segment length, and lane width. In the second approach, a broader set of site characteristics were considered in addition to ADT, segment length, and lane width.

The first approach began by developing an "ADT-only" negative binomial regression model in the form:

$$N = \exp(a + b \ln ADT + \ln L) \qquad \textbf{(1)}$$

where:

N	=	predicted number of crashes per year of a particular crash type
ADT	=	average daily traffic volume (veh/day) on the roadway segment
L	=	length of roadway segment (mi)
a, b	=	regression coefficients

In addition to the ADT term, the "ADT-only" models for roadway segments also included the roadway segment length as a factor representing exposure. Then, models were developed in the same form as Equation (1), but with a set of variables added to represent the effect of lane width:

$$N = \exp(a + b \ln ADT + \ln L + c_9 LW_9 + c_{10} LW_{10} + c_{11} LW_{11} + c_{12} LW_{12} + c_{13+} LW_{13+}) \qquad \textbf{(2)}$$

where:

LW_9	=	indicator variable (= 1 if lane width of roadway segment = 9 ft; = 0 if not)
LW_{10}	=	indicator variable (= 1 if lane width of roadway segment = 10 ft; = 0 if not)
LW_{11}	=	indicator variable (= 1 if lane width of roadway segment = 11 ft; = 0 if not)
LW_{12}	=	indicator variable (= 1 if lane width of roadway segment = 12 ft; = 0 if not)
LW_{13+}	=	indicator variable (= 1 if lane width of roadway segment = 13 ft or more; = 0 if not)
$c_9, ..., c_{13+}$	=	regression coefficients

Lane width was treated as a categorical variable in this modeling approach, rather than as a continuous variable, because there was no reason to presume a linear or loglinear relationship between lane width and safety. Treatment as a categorical variable provides an opportunity for unusual or unexpected relationships between lane width and safety to be identified. Lane width effects were included in models in the form show in Equation (2) only if the effect of lane width was found to be statistically significant.

The second approach began with the "best" models developed in NCHRP Project 17-26 considering variables other than lane width. These models were typically in the form:

$$N = \exp\,(a + b\ \ln ADT + \ln L + d\ SW + e\ OSP + f\ RHR) \quad (3)$$

where:

SW	=	shoulder width (ft)
OSP	=	on-street parking indicator (= 0 if curb parking is present on either side of street; = 1 if not present)
RHR	=	roadside hazard rating for roadway segment (1 to 7 scale)
d, e, f	=	regression coefficients

The shoulder width, on-street parking, and roadside hazard rating variables were included only if their coefficients were statistically significant. The roadside hazard rating used in Project 17-26 was a rating on a scale from 1 (best roadside) to 7 (poorest roadside) developed in research by Zegeer (*8*).

To this "best" model from NCHRP Project 17-26, in the form shown in Equation (3), the current research then added the same lane width effects that were considered in Equation (2):

$$N = \exp\,(a + b\ \ln ADT + \ln L + d\ SW + e\ OSP + f\ RHR + c_9\ LW_9 + c_{10}\ LW_{10} + c_{11}\ LW_{11} + c_{12}\ LW_{12} + c_{13+}\ LW_{13+}) \quad (4)$$

Lane width was added to Equation (4) only if its effect was found to be statistically significant.

Nine dependent variables [represented by N in Equations (1) through (4)] were considered:

- All crashes

- Fatal-and-injury crashes
- Property-damage-only crashes
- All multiple-vehicle crashes (nondriveway-related)
- Fatal-and-injury multiple-vehicle crashes (nondriveway-related)
- Property-damage-only multiple-vehicle crashes
- All single-vehicle crashes
- Fatal-and-injury single-vehicle crashes
- Property-damage-only single-vehicle crashes

Both analysis approaches were applied to:

- 2 model forms [either Equation (1) and (2) or Equations (3) and (4)]
- 9 dependent variables
- 5 roadway types

Thus, a total of 90 regression models were developed for each analysis approach. The results of these modeling approaches are presented below.

Analysis Results

All of the 45 models of Minnesota roadway segment crashes using the "ADT-only" model in the form shown in Equation (1) were statistically significant with R^2_{LR} ranging from 0.08 to 0.45. Lane width variables were added to create models in the form of Equation (2).

Table 3 shows the coefficients of the lane width variables [c_9, c_{10}, c_{11}, c_{12}, and c_{13+} in Equation (2)]. The coefficients are all expressed through comparison to a nominal lane width of 3.6 m (12 ft) (i.e., the value of coefficient c_{12} is always zero). Positive coefficients indicate that roadways with the corresponding lane width would be expected to have higher crash frequencies than roadways with 3.6-m (12-ft) lanes. Negative coefficients indicate that roadways with the corresponding lane width would be expected to have lower crash frequencies than roadways with 3.6-m (12-ft) lanes. The values of the coefficients must be interpreted in accordance with Equation (2). The actual effect of lane width on safety is determined by taking the exponential function of the coefficient [e.g., $\exp(c_{10})$].

The final two columns in Table 3 indicate the results of comparisons of the coefficients for different lane widths. The next-to-last column indicates a comparison of the lane width effects for 2.7- and 3.0-m (9- and 10-ft) lanes to those for 3.3- and 3.6-m (11- and 12-ft) lanes. The comments in the last column of Table 3 (and subsequent tables) are interpreted as follows:

TABLE 3. Negative binomial regression models with ADT and lane width for roadway segments in Minnesota

		Model coefficients										Comments on lane width effect
				Lane width category (ft)								
Roadway type	Number of sites	Intercept	AADT	9	10	11	12	13+	Dispersion	R_{LR}^2	Statistical significance	9 or 10 ft to 11 or 12 ft
All crashes												
2U	380										R^2 below 0.10	
3T	129	–6.56	0.84		–0.56	0.70	0	0.26	0.65	0.13	Significant	Increase
4D	178	–9.15	1.11		–0.04	–0.22	0	–0.52	0.93	0.21	Significant	Inconsistent
4U	440	–15.31	1.79	1.06	0.81	0.40	0	0.43	0.79	0.31	Significant	Decrease
5T	26										No model found	
Fatal-and-injury crashes												
2U	380										No model found	
3T	129										R^2 below 0.10	
4D	178										No model found	
4U	440	–15.43	1.66	0.62	0.57	0.20	0	0.00	0.93	0.17	Significant	Decrease
5T	26										No model found	
Property-damage-only crashes												
2U	380										R^2 below 0.10	
3T	129	–6.78	0.84		–0.26	0.79	0	0.35	0.54	0.12	Significant	Increase
4D	178	–9.73	1.12		–0.04	–0.27	0	–0.62	0.97	0.21	Significant	Inconsistent
4U	440	–15.86	1.82	1.28	0.94	0.49	0	0.63	0.88	0.29	Significant	Decrease
5T	26										No model found	
All multiple-vehicle crashes												
2U	380										No model found	
3T	129										No model found	
4D	178	–10.35	1.21		0.04	–0.23	0	–0.47	1.10	0.20	Significant	No change
4U	439	–17.45	1.98	1.11	0.79	0.33	0	0.39	1.02	0.29	Significant	Decrease
5T	26	–24.90	2.75			–0.86	0		0.08	0.45	Significant	
Fatal-and-injury multiple-vehicle crashes												
2U	380										No model found	
3T	129										No model found	
4D	178										No model found	
4U	439	–17.34	1.83	0.52	0.56	0.14	0	–0.03	1.32	0.15	Significant	Decrease
5T	26										No model found	
Property-damage-only multiple-vehicle crashes												
2U	380										No model found	
3T	129										No model found	
4D	178	–10.82	1.21		–0.04	–0.26	0	–0.55	1.20	0.19	Significant	No change
4U	435	–18.28	2.04	1.39	0.97	0.45	0	0.61	1.17	0.27	Significant	Decrease
5T	26										No model found	

TABLE 3. Negative binomial regression models with ADT and lane width for roadway segments in Minnesota (Continued)

Roadway type	Number of sites	Model coefficients: Intercept	AADT	Lane width category (ft): 9	10	11	12	13+	Dispersion	R_{LR}^2	Statistical significance	Comments on lane width effect: 9 or 10 ft to 11 or 12 ft
All single-vehicle crashes												
2U	380										R^2 below 0.10	
3T	129										No model found	
4D	178	–7.59	0.76		–0.24	–0.22	0	–0.75	0.89	0.10	Significant	Increase
4U	440	–9.40	1.05	0.92	0.91	0.61	0	0.68	0.61	0.13	Significant	Decrease
5T	26										No model found	
Fatal-and-injury single-vehicle crashes												
2U	380										No model found	
3T	129										No model found	
4D	178										No model found	
4U	440	–9.56	0.88	1.11	0.71	0.36	0	0.18	0.14	0.05	Significant	Decrease
5T	26										No model found	
Property-damage-only single-vehicle crashes												
2U	380										R^2 below 0.10	
3T	129										No model found	
4D	178										R^2 below 0.10	
4U	440	–9.80	1.07	0.87	0.97	0.66	0	0.82	0.68	0.11	Significant	Decrease
5T	26										No model found	

NOTE: Coefficients are used in the model form shown in Equation (2)

- *Decrease* means that 3.3- to 3.6-m (11- to 12-ft) lanes have lower crash frequencies than 2.7- to 3.0-m (9- to 10-ft) lanes. This is consistent with the “conventional wisdom” that wider lanes result in lower crash frequencies.
- *Increase* means that 3.3- to 3.6-m (11- to 12-ft) lanes have higher crash frequencies than 2.7- to 3.0-m (9- to 10-ft) lanes. This is opposite to the “conventional wisdom.”
- *No change* means that the crash frequencies for 3.3- to 3.6-m (11- and 12-ft) lanes are so close to those for 2.7- and 3.0-m (9- and 10-ft) lanes that there is little practical engineering difference between these values.
- *Inconsistent* means that the crash frequencies for 2.7- and 3.0-m (9- and 10-ft) lanes fall between those for 3.3- and 3.6-m (11- and 12-ft) lanes.

Table 3 shows that when the lane width variable was added to the 45 statistically significant “ADT-only” models:

- in 17 cases, statistically significant models involving both ADT and lane width were found.
- in 22 cases, no model was found (i.e., the modeling algorithm did not converge). This indicates that the addition of the lane width interfered with the relationship between safety and ADT that had already been determined.
- in 6 cases, statistically significant models were found but the value of R^2_{LR} was so low (below 0.10) that the model has little predictive ability. In these cases, the ADT-only model had R^2_{LR} above 0.10, so the predictive ability of the model including lane width was less than the ADT-only model.

In the 28 cases for which no model was found or a model with R^2_{LR} below 0.10 was found, there is no indication of a strong relationship between lane width and safety. In the 17 cases where both ADT and lane width had a statistically significant effect, there were only nine cases in which the effect for lane width in the range from 2.7 to 3.6 m (9 to 12 ft) was in the direction expected by the conventional wisdom (i.e., decreasing crash frequency for wider lanes). These nine cases included all of the dependent variables considered for one particular roadway type-four-lane undivided roadways. In general, for four-lane undivided roadways on Minnesota arterials, roadways with lane widths of 3.0 m (10 ft) or less were found to have higher crash frequencies than comparable roadways with 3.3- or 3.6-m (11- or 12-ft) lanes. There is no indication in the Minnesota data of a consistent relationship between safety and lane width for any other roadway type. It should be noted that the Minnesota data contain relatively few sites with 2.7-m (9-ft) lanes. Therefore, the finding noted above generally indicates that four-lane undivided arterials in Minnesota with 3.0-m (10-ft) lanes tend to experience more crashes than those with 3.3- and 3.6-m (11- and 12-ft) lanes.

Table 4 presents comparable results to Table 3 for arterial roadway segments in Oakland County, Michigan. The results are comparable to the Minnesota results in that there were only a limited number of statistically significant models incorporating both ADT and lane width. Specifically, out of the 45 cases for which statistically significant “ADT-only” models were found:

- in 25 cases, statistically significant models involving both ADT and lane width were found.
- in 4 cases, statistically significant models were found but the value of R^2_{LR} was below 0.10.
- in 16 cases, no model was found (i.e., the modeling algorithm did not converge).

TABLE 4. Negative binomial regression models with ADT and lane width for roadway segments in Oakland County, Michigan

Roadway type	Number of sites	Model coefficients: Intercept	AADT	Lane width category (ft): 9	10	11	12	13+	Dispersion	R_{LR}^2	Statistical significance	Comments on lane width effect: 9 or 10 ft to 11 or 12 ft
All crashes												
2U	590	–10.14	1.27	0.07	–0.19	–0.24	0	–0.18	0.37	0.43	Significant	No change
3T	100	–8.92	1.11	0.02	–0.23	–0.24	0	–0.78	0.31	0.50	Significant	No change
4D	140	–7.36	0.96	0.39	–0.98	0.10	0	–0.21	0.68	0.23	Significant	Inconsistent[a]
4U	440	–3.94	0.60	–0.22	0.23	0.69	0		0.52	0.18	Significant	Inconsistent
5T	549	–7.58	1.03		–0.63	0.04	0	–0.10	0.62	0.18	Significant	Increase
Fatal-and-injury crashes												
2U	590	–11.71	1.28	–0.35	–0.18	–0.43	0	–0.24	0.25	0.29	Significant	No change
3T	100										No model found	
4D	140	–8.96	0.98	1.12	–1.98	–0.14	0	–0.03	0.57	0.20	Significant	Inconsistent[a]
4U	440										R^2 below 0.10	
5T	549										No model found	
Property-damage-only crashes												
2U	590	–10.32	1.26	0.21	–0.15	–0.19	0	–0.14	0.40	0.39	Significant	Inconsistent[a]
3T	100	–8.43	1.02	0.03	–0.17	–0.21	0	–0.91	0.30	0.46	Significant	Inconsistent
4D	140	–7.45	0.94	0.13	–0.85	0.16	0	–0.29	0.66	0.23	Significant	Inconsistent
4U	440	–3.99	0.58	–0.19	0.27	0.74	0		0.55	0.16	Significant	Inconsistent
5T	549	–8.06	1.05		–0.69	0.04	0	–0.12	0.63	0.18	Significant	Increase
All multiple-vehicle crashes												
2U	588	–13.88	1.63	0.07	–0.24	–0.42	0	–0.11	0.56	0.43	Significant	Inconsistent[b]
3T	100	–9.93	1.20	0.10	–0.24	–0.36	0	–0.73	0.42	0.47	Significant	Inconsistent[b]
4D	140	–11.34	1.33	0.75	–0.73	0.05	0	–0.31	0.84	0.26	Significant	Inconsistent[a]
4U	438	–4.98	0.67	0.08	0.57	0.98	0		0.57	0.18	Significant	Inconsistent
5T	549	–8.45	1.11		–0.66	0.06	0	–0.09	0.73	0.18	Significant	Increase
Fatal-and-injury multiple-vehicle crashes												
2U	590	–16.16	1.72	–0.48	–0.34	–0.54	0	–0.21	0.37	0.32	Significant	Inconsistent
3T	100										No model found	
4D	140	–10.90	1.16	1.41	–1.67	–0.06	0	0.05	0.60	0.21	Significant	Inconsistent[a]
4U	440	–7.45	0.79	0.02	0.50	0.88	0		0.75	0.10	Significant	No change
5T	549										No model found	
Property-damage-only multiple-vehicle crashes												
2U	585	–13.83	1.60	0.27	–0.15	–0.39	0	–0.04	0.62	0.38	Significant	Inconsistent[a]
3T	100	–9.37	1.11	0.08	–0.18	–0.33	0	–0.90	0.42	0.43	Significant	Inconsistent
4D	140	–11.53	1.31	0.44	–0.63	0.08	0	–0.45	0.84	0.26	Significant	Inconsistent[a]
4U	438	–5.20	0.66	0.11	0.59	1.00	0		0.60	0.16	Significant	No change
5T	548	–8.82	1.12		–0.70	0.05	0	–0.12	0.77	0.17	Significant	Increase

TABLE 4. Negative binomial regression models with ADT and lane width for roadway segments in Oakland County, Michigan (Continued)

		Model coefficients										Comments on lane width effect
				Lane width category (ft)								
Roadway type	Number of sites	Intercept	AADT	9	10	11	12	13+	Dispersion	R_{LR}^2	Statistical significance	9 or 10 ft to 11 or 12 ft
All single-vehicle crashes												
2U	590										R^2 below 0.10	
3T	100										No model found	
4D	140										No model found	
4U	440										No model found	
5T	549										No model found	
Fatal-and-injury single-vehicle crashes												
2U	590										No model found	
3T	100										No model found	
4D	140										No model found	
4U	440										R^2 below 0.10	
5T	549										No model found	
Property-damage-only single-vehicle crashes												
2U	590										R^2 below 0.10	
3T	100										No model found	
4D	140										No model found	
4U	440										No model found	
5T	549										No model found	

[a] Substantially more crashes for 9-ft lanes than for 10-ft lanes.
[b] A few more crashes for 9-ft lanes than for 10-ft lanes.
NOTE: Coefficients are used in the model form shown in Equation (2)

The Michigan data do *not* show a lane width effect for four-lane undivided roadways similar to that found in Minnesota. Four-lane undivided roadways with 3.0-m (10-ft) lanes in Michigan generally had crash frequencies comparable to roadways with 3.3- and 3.6-m (11- and 12-ft) lanes. The only pattern noted was that for four-lane divided arterials in Michigan, roadways with 2.7-m (9-ft) lanes tend to have higher crash frequencies than roadways with 3.0-m (10-ft) lanes.

Table 5 presents the results of the modeling of Minnesota roadway segment crashes using the second approach discussed above. The table shows the comparison of 45 pairs of models (nine dependent variables for each of five roadway types). Each pair of models includes, on the first line, the "best" of the base models from NCHRP Project 17-26. These models are in the form shown in Equation (3); all of the base models include ADT and they also include the effects of on-street parking, shoulder width, and/or roadside hazard rating if these effects were statistically significant. The second line for each pair of models includes the same model shown in the first line with the lane width variables added in the form shown in Equation (4).

The results for the 45 pairs of models indicate that:

- in 16 cases, the lane width term added to the base model was statistically significant.
- in one case, the lane width term added to the model was statistically significant but resulted in a model with a value of R^2_{LR} so low (below 0.10) that the model has little predictive power.
- in 28 cases, no model was found when the lane width term was added to the base model (i.e., the modeling algorithm did not converge).

For the models including lane width that were statistically significant, the only consistent pattern observed was the higher crash frequencies for 2.7- to 3.0-m (9- to 10-ft) lanes on four-lane undivided arterials also observed in Table 3.

Table 6 shows results comparable to Table 5 for arterial roadway segments in Oakland County, Michigan. The results for the 45 pairs of models indicate that:

- in 21 cases, the lane width term added to the base model was statistically significant.
- in 2 cases, the lane width term added to the model was statistically significant but resulted in a model with a value of R^2_{LR} below 0.10.
- in 22 cases, no model was found when the lane width term was added to the base model (i.e., the modeling algorithm did not converge)

There is no indication in the Michigan data of elevated crash frequencies for 3.0 m (10-ft) lanes on four-lane undivided roadways as found for Minnesota. There is an indication in the Michigan data that higher crash frequencies may be found for 2.7- than for 3.0-m (9- than for 10-ft) lanes on four-lane divided arterials. There are no other consistent results.

SAFETY EVALUATION OF LANE WIDTHS ON ARTERIAL INTERSECTION APPROACHES

Available Database

An analysis similar to that for arterial midblock sections presented above has also been performed for lane widths on approaches to arterial intersections. The database from NCHRP Project 17-26 discussed above as part of the midblock segment study that was used in this

TABLE 5. Negative binomial regression models with ADT, other independent variables, and lane width for roadway segments in Minnesota

Roadway type	Model type	Independent variables in model	Number of sites	Base model coefficients: Intercept	AADT	Curb parking: None	Curb parking: Either side	Shoulder width	Roadside rating	Dispersion	R_{LR}^2	Lane width coefficients: 9	10	11	12	13+	Statistical significance	Comments on lane width effect: 9 or 10 ft to 11 or 12 ft
All crashes																		
2U	B	SWandRR	458	–6.66	0.84			-0.04	0.14	0.89	0.18						Significant	
2U	B+LWC	LWCandSWandRR	377	–5.68	0.69			-0.03	0.21	0.78	0.21		–0.12	–0.80	0.00	-0.15	Significant	Inconsistent
3T	B	ShoulderW	262	–8.94	1.14			-0.08		0.84	0.14						Significant	
3T	B+LWC																No model found	
4D	B	ShoulderW	379	–10.31	1.26			-0.04		0.78	0.25						Significant	
4D	B+LWC	LWCandSW	174	–10.98	1.32			-0.07		0.89	0.26		–0.42	–0.69	0.00	-0.66	Significant	Inconsistent
4U	B	SWandRR	701	–13.37	1.55			-0.06	0.13	0.96	0.26						Significant	
4U	B+LWC	LWCandSWandRR	440	–15.37	1.74			-0.03	0.13	0.76	0.33	1.03	0.56	0.30	0.00	0.27	Significant	Decrease
5T	B	ShoulderW	169	–8.16	1.03			-0.10		0.82	0.10						Significant	
5T	B+LWC																No model found	
Fatal-and-injury crashes																		
2U	B	ShoulderW	462														R^2 below 0.10	
2U	B+LWC																No model found	
3T	B	ShoulderW	262														R^2 below 0.10	
3T	B+LWC																No model found	
4D	B	ShoulderW	379	–11.90	1.31			-0.05		0.95	0.17						Significant	
4D	B+LWC																No model found	
4U	B	AADTonly	742	–13.96	1.54					1.16	0.14						Significant	
4U	B+LWC	LWC	440	–15.43	1.66					0.93	0.17	0.62	0.57	0.20	0.00	0.00	Significant	Decrease
5T	B	AADTonly	205														Significant	
5T	B+LWC																No model found	
Property-damage-only crashes																		
2U	B	CPandSW	462	–7.20	0.99	-1.07	0	-0.02		0.79	0.24						Significant	
2U	B+LWC																No model found	
3T	B	ShoulderW	262	–9.70	1.19			-0.08		0.90	0.13						Significant	
3T	B+LWC																No model found	
4D	B	ShoulderW	379	–10.48	1.24			-0.04		0.86	0.22						Significant	
4D	B+LWC	LWCandSW	174	–11.61	1.34			-0.08		0.91	0.27		–0.46	–0.79	0.00	-0.80	Significant	Inconsistent
4U	B	SWandRR	701	–14.69	1.64			-0.08	0.16	1.08	0.25						Significant	
4U	B+LWC	LWCandSWandRR	440	–15.98	1.76			-0.05	0.16	0.83	0.32	1.22	0.63	0.36	0.00	0.43	Significant	Decrease
5T	B	ShoulderW	169														R^2 below 0.10	
5T	B+LWC																No model found	
All multiple-vehicle crashes																		
2U	B	CPandSW	451	–11.05	1.36	-0.79	0	-0.02		1.19	0.20						Significant	
2U	B+LWC																No model found	
3T	B	ShoulderW	261	–14.66	1.74			-0.11		0.97	0.20						Significant	
3T	B+LWC																No model found	
4D	B	ShoulderW	378	–12.33	1.45			-0.05		0.94	0.26						Significant	
4D	B+LWC	LWCandSW	174	–12.40	1.45			-0.08		1.05	0.25		–0.37	–0.75	0.00	-0.60	Significant	Inconsistent
4U	B	ShoulderW	700	–15.27	1.78			-0.10		1.24	0.24						Significant	
4U	B+LWC	LWCandSW	439	–17.87	2.03			-0.06		1.00	0.30	1.01	0.71	0.31	0.00	0.36	Significant	Decrease
5T	B	ShoulderW	168	–8.58	1.05			-0.17		0.80	0.12						Significant	
5T	B+LWC																No model found	
Fatal-and-injury multiple-vehicle crashes																		
2U	B	ShoulderW	459														R^2 below 0.10	
2U	B+LWC																No model found	
3T	B	ShoulderW	262	–15.40	1.68			-0.10		1.16	0.10						Significant	
3T	B+LWC																No model found	
4D	B	ShoulderW	377	–13.17	1.42			-0.06		1.10	0.16						Significant	
4D	B+LWC																No model found	
4U	B	ShoulderW	700	–14.97	1.63			-0.08		1.57	0.12						Significant	
4U	B+LWC	LWCandSW	439	–17.74	1.88			-0.06		1.30	0.15	0.43	0.48	0.13	0.00	-0.05	Significant	Decrease
5T	B	AADTonly	204														R^2 below 0.10	

TABLE 5. Negative binomial regression models with ADT, other independent variables, and lane width for roadway segments in Minnesota (Continued)

Roadway type	Model type	Independent variables in model	Number of sites	Base model coefficients: Intercept	AADT	Curb parking: None	Curb parking: Either side	Shoulder width	Roadside rating	Dispersion	R_{LR}^2	Lane width coefficients: 9	10	11	12	13+	Statistical significance	Comments on lane width effect: 9 or 10 ft to 11 or 12 ft
5T	B+LWC																No model found	
Property-damage-only multiple-vehicle accidents																		
2U	B	CPandSW	453	–12.69	1.52	-0.91	0	-0.04		1.15	0.20						Significant	
2U	B+LWC																No model found	
3T	B	ShoulderW	261	–14.80	1.71			-0.11		1.03	0.18						Significant	
3T	B+LWC																No model found	
4D	B	ShoulderW	378	–12.59	1.43			-0.05		1.05	0.23						Significant	
4D	B+LWC	LWCandSW	174	–12.97	1.47			-0.09		1.13	0.25		–0.50	–0.85	0.00	–0.72	Significant	Inconsistent
4U	B	ShoulderW	696	–16.54	1.88			-0.10		1.47	0.21						Significant	
4U	B+LWC	LWCandSW	435	–18.57	2.07			-0.06		1.15	0.28	1.31	0.89	0.44	0.00	0.58	Significant	Decrease
5T	B	ShoulderW	169	–8.10	0.97			-0.23		0.96	0.11						Significant	
5T	B+LWC																No model found	
All single-vehicle crashes																		
2U	B	CPandRR	564	–3.00	0.41	-0.98	0		0.10	0.76	0.15						Significant	
2U	B+LWC	LWCandCPandRR	377	–1.03	0.17	-1.09	0		0.15	0.45	0.24		–0.55	–0.37	0.00	–0.31	Significant	Increase
3T	B	AADTonly	380														R^2 below 0.10	
3T	B+LWC																No model found	
4D	B	CPandRR	536														R^2 below 0.10	
4D	B+LWC																No model found	
4U	B	CPandRR	742	–9.64	1.03	-0.63	0		0.14	0.77	0.15						Significant	
4U	B+LWC	LWCandCPandRR	440	–7.68	0.83	-0.47	0		0.12	0.51	0.17	0.76	0.64	0.32	0.00	0.31	Significant	Decrease
5T	B	AADTonly	205														R^2 below 0.10	
5T	B+LWC																No model found	
Fatal-and-injury single-vehicle crashes																		
2U	B																No model found	
2U	B+LWC																No model found	
3T	B																No model found	
3T	B+LWC																No model found	
4D	B	RSRating	536														R^2 below 0.10	
4D	B+LWC																No model found	
4U	B	CPandRR	742														R^2 below 0.10	
4U	B+LWC	LWCandCPandRR	440														R^2 below 0.10	
5T	B																No model found	
5T	B+LWC																No model found	
Property-damage-only single-vehicle crashes																		
2U	B	CPandRR	564	–4.46	0.55	-1.11	0		0.11	0.74	0.16						Significant	
2U	B+LWC	LWCandCPandRR	377	–2.40	0.31	-1.24	0		0.14	0.44	0.24		–0.76	–0.49	0.00	–0.41	Significant	Increase
3T	B	AADTonly	380	–6.37	0.63					1.34	0.02						R^2 below 0.10	
3T	B+LWC																No model found	
4D	B	CPandRR	536	–5.94	0.56	-0.38	0		0.20	0.98	0.06						R^2 below 0.10	
4D	B+LWC	LWCandCPandRR	178	–4.53	0.35	-0.41	0		0.44	0.70	0.19		–0.69	–0.88	0.00	–0.48	Significant	Inconsistent
4U	B	CPandRR	742	–10.86	1.13	-0.68	0		0.14	0.87	0.14						Significant	
4U	B+LWC	LWCandCPandRR	440	–8.08	0.86	-0.47	0		0.11	0.56	0.15	0.70	0.70	0.37	0.00	0.45	Significant	Decrease
5T	B	AADTonly	205														R^2 below 0.10	
5T	B+LWC																No model found	

NOTE: Base model (B) coefficients are used in the model form shown in Equation (3).
Base model plus lane width (B+LWC) coefficients are used in the model form shown in Equation (4).

TABLE 6. Negative binomial regression models with ADT, other independent variables, and lane width for roadway segments in Oakland County, Michigan

Roadway type	Model type	Independent variables in model	Number of sites	Base model coefficients						Dispersion	R_{LR}^2	Lane width coefficients					Statistical significance	Comments on lane width effect
				Intercept	AADT	Curb parking: None	Curb parking: Either side	Shoulder width	Roadside rating			9	10	11	12	13+		9 or 10 ft to 11 or 12 ft
All crashes																		
2U	B	ShoulderW	590	–10.53	1.33			–0.01		0.39	0.42						Significant	
2U	B+LWC																No model found	
3T	B	ShoulderW	100	–9.03	1.19			–0.04		0.33	0.47						Significant	
3T	B+LWC	LWCandSW	100	–9.43	1.18			–0.03		0.29	0.51	–0.10	–0.28	–0.34	0	–0.69	Significant	Inconsistent
4D	B	AADTonly	140	–6.17	0.86					0.75	0.17						Significant	
4D	B+LWC	ShoulderW	140	–6.01	0.85			–0.18		0.74	0.18						Not significant	
4U	B	Parking2	440														R^2 below 0.10	
4U	B+LWC	LWCandCP	440	–3.65	0.62	–0.42	0			0.51	0.19	–0.24	0.16	0.68	0		Significant	Inconsistent
5T	B	ShoulderW	549	–7.82	1.07			–0.08		0.62	0.19						Significant	
5T	B+LWC	LWCandSW	549	–7.59	1.05			–0.08		0.61	0.20		–0.64	0.03	0	0.02	Significant	Increase
Fatal-and-injury crashes																		
2U	B	AADTonly	590	–12.31	1.35					0.28	0.27						Significant	
2U	B+LWC	LWC	590	–11.71	1.28					0.25	0.29	–0.35	–0.18	–0.43	0	–0.24	Significant	Inconsistent
3T	B	AADTonly	100	–13.58	1.48					0.38	0.35						Significant	
3T	B+LWC																No model found	
4D	B	AADTonly	140														R^2 below 0.10	
4D	B+LWC	LWC	140	–8.96	0.98					0.57	0.20	1.12	–1.98	–0.14	0	–0.03	Significant	Inconsistent[a]
4U	B	AADTonly	440														R^2 below 0.10	
4U	B+LWC	LWC	440	–6.83	0.77					0.67	0.09	–0.30	0.13	0.53	0		Significant	Inconsistent
5T	B	ShoulderW	549	–8.65	1.01			–0.07		0.60	0.13						Significant	
5T	B+LWC																No model found	
Property-damage-only crashes																		
2U	B	ShoulderW	590	–10.52	1.30			–0.01		0.42	0.38						Significant	
2U	B+LWC																No model found	
3T	B	ShoulderW	100	–8.69	1.14			–0.05		0.32	0.44						Significant	
3T	B+LWC	LWCandSW	100	–9.10	1.12			–0.04		0.27	0.48	–0.14	–0.22	–0.35	0	–0.80	Significant	Inconsistent
4D	B	AADTonly	140	–6.77	0.90					0.73	0.18						Significant	
4D	B+LWC	LWC	140	–7.45	0.94					0.66	0.23	0.13	–0.85	0.16	0	–0.29	Significant	Inconsistent[b]
4U	B	Parking2	440														R^2 below 0.10	
4U	B+LWC	LWCandCP	440	–3.65	0.59	–0.51	0			0.53	0.18	–0.21	0.18	0.73	0		Significant	Inconsistent
5T	B	ShoulderW	549	–8.27	1.09			–0.07		0.63	0.18						Significant	
5T	B+LWC	LWCandSW	549	–8.06	1.07			–0.07		0.62	0.19		–0.70	0.03	0	0.00	Significant	Increase
All multiple-vehicle crashes																		
2U	B	ShoulderW	588	–14.75	1.73			–0.02		0.61	0.42						Significant	
2U	B+LWC	LWCandSW	588	–14.08	1.67			–0.02		0.56	0.43	0.00	–0.26	–0.41	0	–0.08	Significant	Inconsistent
3T	B	ShoulderW	100	–10.03	1.29			–0.04		0.44	0.45						Significant	
3T	B+LWC	LWCandSW	100	–10.50	1.29			–0.04		0.40	0.48	–0.03	–0.29	–0.49	0	–0.62	Significant	Inconsistent
4D	B	AADTonly	140	–8.84	1.11					0.92	0.20						Significant	
4D	B+LWC	LWC	140	–11.34	1.33					0.84	0.26	0.75	–0.73	0.05	0	–0.31	Significant	Inconsistent[a]
4U	B	CPandSW	438														R^2 below 0.10	
4U	B+LWC																No model found	
5T	B	ShoulderW	549	–8.68	1.14			–0.08		0.73	0.18						Significant	
5T	B+LWC	LWCandSW	549	–8.45	1.12			–0.08		0.72	0.19		–0.67	0.05	0	0.03	Significant	Increase
Fatal-and-injury multiple-vehicle crashes																		
2U	B	AADTonly	590	–17.11	1.81					0.43	0.30						Significant	
2U	B+LWC	LWC	590	–16.16	1.72					0.37	0.32	–0.48	–0.34	–0.54	0	–0.21	Significant	Inconsistent
3T	B	AADTonly	100	–14.81	1.59					0.47	0.33						Significant	
3T	B+LWC																No model found	
4D	B	AADTonly	140	–8.13	0.88					0.82	0.10						Significant	
4D	B+LWC	LWC	140	–10.90	1.16					0.60	0.21	1.41	–1.67	–0.06	0	0.05	Significant	Inconsistent[a]
4U	B	AADTonly	440														R^2 below 0.10	
4U	B+LWC	LWC	440	–7.45	0.79					0.75	0.10	0.02	0.50	0.88	0		Significant	Inconsistent
5T	B	ShoulderW	548	–9.60	1.09			–0.07		0.64	0.13						Significant	

TABLE 6. Negative binomial regression models with ADT, other independent variables, and lane width for roadway segments in Oakland County, Michigan (Continued)

Roadway type	Model type	Independent variables in model	Number of sites	Base model coefficients: Intercept	AADT	Curb parking: None	Curb parking: Either side	Shoulder width	Roadside rating	Dispersion	R_{LR}^2	Lane width coefficients: 9	10	11	12	13+	Statistical significance	Comments on lane width effect: 9 or 10 ft to 11 or 12 ft
5T	B+LWC																No model found	
Property-damage-only multiple-vehicle accidents																		
2U	B	ShoulderW	585	–14.51	1.68			–0.02		0.67	0.36						Significant	
2U	B+LWC																No model found	
3T	B	ShoulderW	100	–9.64	1.23			–0.06		0.43	0.41						Significant	
3T	B+LWC	LWCandSW	100	–10.11	1.22			–0.05		0.38	0.45	–0.09	–0.24	–0.50	0	–0.77	Significant	Inconsistent
4D	B	AADTonly	140	–9.91	1.20					0.90	0.22						Significant	
4D	B+LWC	LWC	140	–11.53	1.31					0.84	0.26	0.44	–0.63	0.08	0	–0.45	Significant	Inconsistent[a]
4U	B	CPandSW	438														R^2 below 0.10	
4U	B+LWC	LWCandCPand	438	–4.56	0.66	–0.51	0	–0.23		0.58	0.18	–0.09	0.33	0.83	0		Significant	Inconsistent[b]
5T	B	ShoulderW	548	–9.02	1.15			–0.08		0.76	0.17						Significant	
5T	B+LWC	LWCandSW	548	–8.81	1.13			–0.07		0.76	0.18		–0.70	0.05	0	0.00	Significant	Increase
All single-vehicle crashes																		
2U	B	AADTonly	590														R^2 below 0.10	
2U	B+LWC	LWC	590														R^2 below 0.10	
3T	B	AADTonly	100	–4.59	0.48					0.57	0.04						R^2 below 0.10	
3T	B+LWC																No model found	
4D	B																No model found	
4D	B+LWC																No model found	
4U	B																No model found	
4U	B+LWC																No model found	
5T	B	ShoulderW	549														R^2 below 0.10	
5T	B+LWC																No model found	
Fatal-and-injury single-vehicle crashes																		
2U	B	AADTonly	590														R^2 below 0.10	
2U	B+LWC																No model found	
3T	B	AADTonly	100														R^2 below 0.10	
3T	B+LWC																No model found	
4D	B																No model found	
4D	B+LWC																No model found	
4U	B																No model found	
4U	B+LWC																No model found	
5T	B																No model found	
5T	B+LWC																No model found	
Property-damage-only single-vehicle crashes																		
2U	B	AADTonly	590														R^2 below 0.10	
2U	B+LWC	LWC	590														R^2 below 0.10	
3T	B	AADTonly	100														R^2 below 0.10	
3T	B+LWC																No model found	
4D	B																No model found	
4D	B+LWC																No model found	
4U	B																No model found	
4U	B+LWC																No model found	
5T	B	ShoulderW	549														R^2 below 0.10	
5T	B+LWC																No model found	

[a] Substantially more crashes for 9-ft lanes than for 10-ft lanes.
[b] A few more crashes for 9-ft lanes than for 10-ft lanes.

NOTE: Base model (B) coefficients are used in the model form shown in Equation (3).
Base model plus lane width (B+LWC) coefficients are used in the model form shown in Equation (4).

research also includes data for arterial intersections and their approaches. The NCHRP Project 17-26 database includes site characteristics, traffic volume, and crash data for approaches to arterial intersections in Minnesota and North Carolina. The intersections in Minnesota are all located in the Minneapolis-St. Paul metropolitan area. The intersections in North Carolina are all located in the City of Charlotte. Both the Minnesota and North Carolina intersections include a mixture of urban and suburban areas. The arterial or major-road approaches to the intersections in Minnesota include a mixture of roadways under state and local jurisdiction. Most of the arterial or major-road approaches in Charlotte are roadways under local jurisdiction. In both areas, the minor-road approaches to the intersections are primarily roads under local jurisdiction.

The available data include four intersection types:

- three-leg signalized intersections (3SG)
- three-leg intersections with minor-road STOP control (3ST)
- four-leg signalized intersections (4SG)
- four-leg intersections with minor-road STOP control (4ST)

Table 7 presents a summary of the number of intersection approaches for which site characteristics including lane width, traffic volume, and crash data are available in each state. Data are available for a total of 1,342 intersection approaches (707 in Minnesota and 635 in North Carolina).

TABLE 7. Number of intersection approach analysis sites by roadway type and lane width category

Intersection type	Number of intersection approaches by lane width category (ft)					
	9	10	11	12	13+	Total
MINNESOTA						
3SG	8	6	21	40	21	96
3ST	4	7	21	36	55	123
4SG	25	32	49	102	88	296
4ST	2	7	16	54	113	192
Subtotal	39	52	107	232	277	707
NORTH CAROLINA						
3SG	8	29	49	27	13	126
3ST	11	26	36	28	40	141
4SG	6	32	75	39	24	176
4ST	10	30	66	28	58	192
Subtotal	35	117	226	122	135	635
TOTAL	74	169	333	354	412	1,342

The lane widths at these sites were measured in the field. The lane width categories shown in the table represent the average lane width across all through travel lanes on a particular intersection approach. Intersection approaches for which measured lane widths were not available have been omitted from Table 7 and from the subsequent analyses. The lane width categories shown in the table are defined identically to the lane width categories used in the roadway segment study described above.

Lane width category	Range of lane widths (ft)
9	9.5 or less
10	9.5 – 10.5
11	10.5 – 11.5
12	11.5 – 12.5
13+	12.5 or more

Crash data were obtained for all of the sites shown in Table 7 for a five-year period: 1998 to 2002 in Minnesota and 1999 to 2003 in North Carolina. The crash data included 2,653 crashes in Minnesota and 8,742 crashes in North Carolina.

Analysis Approach

An approach to cross-sectional analysis similar to that used for roadway segments in Equations (1) and (2) was applied to examine the effect of lane width on intersection approaches. This approach was applied separately to data from each state and each intersection type. In this approach, only two variables were considered: average daily traffic (ADT) volume and lane width. The second approach, used for roadway segments, in which a broader set of site characteristic variables were considered in addition to ADT and lane width, was not applied for intersection approaches because no site characteristics other than lane width and ADT were statistically significant.

The analysis began by developing an "ADT-only" negative binomial regression model in the form:

$$N = \exp(a + b \ln ADT) \quad \textbf{(5)}$$

where:

N	=	predicted number of crashes per year of a particular crash type
ADT	=	average daily traffic volume (veh/day) on the intersection approach
a, b	=	regression coefficients

Then, models were developed in the same form as Equation (5), but with a set of variables added to represent the effect of lane width:

$$N = \exp(a + b \ln ADT + \ln L + c_9 LW_9 + c_{10} LW_{10} + c_{11} LW_{11} + c_{12} LW_{12} + c_{13+} LW_{13+}) \quad \textbf{(6)}$$

where:

LW_9	=	indicator variable (= 1 if lane width of intersection approach = 9 ft; = 0 if not)
LW_{10}	=	indicator variable (= 1 if lane width of intersection approach = 10 ft; = 0 if not)
LW_{11}	=	indicator variable (= 1 if lane width of intersection approach = 11 ft; = 0 if not)
LW_{12}	=	indicator variable (= 1 if lane width of intersection approach = 12 ft; = 0 if not)

LW_{13+}	=	indicator variable (= 1 if lane width of intersection approach = 13 ft or more; = 0 if not)
c_9, ..., c_{13+}	=	regression coefficients

As in the roadway segment study, lane width for intersection approaches was treated as a categorical variable, rather than as a continuous variable, to provide an opportunity for unusual or unexpected relationships between lane width and safety to be identified. Lane width was added to Equation (6) only if its effect was found to be statistically significant.

Six dependent variables [represented by N in Equations (5) and (6)] were considered:

- All crashes
- Fatal-and-injury crashes
- Property-damage-only crashes
- All multiple-vehicle crashes
- Fatal-and-injury multiple-vehicle crashes
- Property-damage-only multiple-vehicle crashes

Analyses were conducted for single-vehicle crashes but have been omitted here because the frequencies of single-vehicle crashes on intersection approaches were very low. Few statistically significant results were expected for models of single–vehicle crashes. The analysis was applied to:

- 6 dependent variables
- 4 intersection types

Thus, a total of 24 regression models were developed for this analysis approach. The modeling results are presented below.

Analysis Results

All but 2 of the 24 models of Minnesota intersection crashes using the “ADT-only” model in the form shown in Equation (5) were statistically significant with R^2_{LR} ranging from 0.17 to 0.65. Table 8 shows the analysis results when lane width variables were added to create models in the form of Equation (6).

In the six cases in which a statistically significant ADT and lane width effect was found, there were four cases in which the effect for lane width in the range from 2.7 to 3.6 m (9 to 12 ft) was in the direction expected by conventional wisdom (i.e., decreasing crash frequency for wider lanes). These four cases included most of the dependent variables considered for one particular intersection type—four-leg STOP-controlled intersections. In general, for approaches to four-leg STOP-controlled intersections on Minnesota arterials, intersection approaches with lane widths of 3.0 m (10 ft) or less were found to have higher crash frequencies than comparable approaches with 3.3- or 3.6-m (11- or 12-ft) lanes. There is no indication in the Minnesota data of a consistent relationship between safety and lane width for any other intersection approach type. It should be noted that the Minnesota data contain relatively few sites with 2.7-m (9-ft) lanes.

TABLE 8. Negative binomial regression models with ADT and lane width for intersection approaches in Minnesota

		Model coefficients										Comments on lane width effect
				Lane width coefficients								
Intersection type	Number of sites	Intercept	AADT	9	10	11	12	13+	Dispersion	R_{LR}^2	Statistical significance	9 or 10 ft to 11 or 12 ft
All crashes												
3SG	96										No model found	
3ST	123										No model found	
4SG	296										No model found	
4ST	192	11.52	1.16		0.66	–0.49	0	0.21	0.18	0.67	Significant	Decrease
Fatal-and-injury crashes												
3SG	96	–12.99	1.14		–0.16	–0.20	0	–0.92	0.33	0.49	Significant	Inconsistent
3ST	123										No model found	
4SG	296										No model found	
4ST	192										No model found	
Property-damage-only crashes												
3SG	96										No model found	
3ST	123										No model found	
4SG	296										No model found	
4ST	192	–11.77	1.14		0.84	–0.49	0	0.33	0.23	0.58	Significant	Decrease
All multiple-vehicle crashes												
3SG	96										No model found	
3ST	123										No model found	
4SG	296										No model found	
4ST	192	–12.02	1.19		0.58	–0.42	0	0.25	0.18	0.65	Significant	Decrease
Fatal-and-injury multiple-vehicle crashes												
3SG	96	–13.15	1.14		–0.11	–0.24	0	–1.05	0.27	0.51	Significant	Inconsistent
3ST	123										No model found	
4SG	296										No model found	
4ST	192										No model found	
Property-damage-only multiple-vehicle crashes												
3SG	96										No model found	
3ST	123										No model found	
4SG	296										No model found	
4ST	192	–12.58	1.21		0.80	–0.49	0	0.39	0.29	0.55	Significant	Decrease

NOTE: Coefficients are used in the model form shown in Equation (6)

Therefore, the finding noted above generally indicates that approaches to four-leg STOP-controlled intersections with 3.0-m (10-ft) lanes tend to experience more crashes than those with 3.3- and 3.6-m (11- and 12-ft) lanes.

Table 9 presents comparable results to Table 8 for intersection approaches in Charlotte, North Carolina. The results are comparable to the Minnesota results in that there were only a limited number of statistically significant models incorporating both ADT and lane width. Specifically, out of the 22 cases for which statistically significant "ADT-only" models were found:

- in only 6 cases, statistically significant models involving both ADT and lane width were found.
- in 18 cases, no model was found when lane width was added to the "ADT-only" model (i.e., the modeling algorithm did not converge).

As in the case of the Minnesota data for intersection approaches, the Charlotte data show statistically significant effects for the differences between 2.7-, 3.0-, and 3.6-m (9-, 10- and 12-ft) lanes primarily for approaches to four-leg STOP-controlled intersections. However, the Charlotte data do *not* show a lane width effect for four-leg STOP-controlled intersections similar to that found in Minnesota. In contrast to the Minnesota finding, the Charlotte data indicate that approaches to four-leg STOP-controlled intersections show higher crash frequencies for approaches with 3.6-m (12-ft) lanes than for comparable approaches with 2.7- to 3.0-m (9- to 10-ft) lanes. In other words, the only statistically significant results for Charlotte intersections show lane width effects that are opposite to the conventional wisdom that wider lanes have lower crash experience.

INTERPRETATION OF RESULTS

Lane Widths on Arterial Roadway Segments

Analysis of geometric design, traffic volume, and accident data collected in NCHRP Project 17-26 has found that, with limited exceptions, there is no consistent, statistically significant relationship between lane width and safety for midblock sections of urban and suburban arterials. There is no indication that the use of 3.0- or 3.3-m (10- or 11-ft lanes), rather than 3.6-m (12-ft) lanes, for arterial midblock segments leads to increases in accident frequency. There are situations in which use of narrower lanes may provide benefits in traffic operations, pedestrian safety, and/or reduced interference with surrounding development, and may provide space for geometric features that enhance safety such as medians or turn lanes. The analysis results indicate narrow lanes can generally be used to obtain these benefits without compromising safety.

Two caveats should be noted. First, the data for one of the states analyzed showed an increase in crash rates for four-lane undivided arterials with lane widths of 3.0 m (10 ft) or less, while the data from another state showed an increase in crash rates for four-lane divided arterials with lane widths or 2.7 m (9 ft) or less. While the results from each state were not confirmed in data from the other state, the findings indicate that lane widths of 3.0 m (10 ft) or less on four-lane undivided arterials and lane widths of 2.7 m (9 ft) or less on four-lane divided arterials should be used cautiously unless local experience indicates otherwise. Second, until more is

TRB 2007 Annual Meeting CD-ROM

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TABLE 9. Negative binomial regression models with ADT and lane width for intersection approaches in Charlotte, North Carolina

Intersection type	Number of sites	Model coefficients: Intercept	AADT	Lane width coefficients: 9	10	11	12	13+	Dispersion	R_{LR}^2	Statistical significance	Comments on lane width effect: 9 or 10 ft to 11 or 12 ft
All crashes												
3SG	126										No model found	
3ST	141										No model found	
4SG	176										No model found	
4ST	192	–5.96	0.63	–1.89	–0.37	–0.31	0	–0.51	0.71	0.51	Significant	Increase
Fatal-and-injury crashes												
3SG	126										No model found	
3ST	141										No model found	
4SG	176										No model found	
4ST	192	–7.67	0.69	–2.02	–0.15	–0.18	0	–0.74	0.80	0.43	Significant	Inconsistent
Property-damage-only crashes												
3SG	126										No model found	
3ST	141										No model found	
4SG	176										No model found	
4ST	192	–6.14	0.61	–1.86	–0.49	–0.39	0	–0.40	0.67	0.45	Significant	Increase
All multiple-vehicle crashes												
3SG	126										No model found	
3ST	141										No model found	
4SG	176										No model found	
4ST	192	–6.67	0.71	–1.87	–0.50	–0.29	0	–0.41	0.79	0.51	Significant	Increase
Fatal-and-injury multiple-vehicle crashes												
3SG	126										No model found	
3ST	141										No model found	
4SG	176										No model found	
4ST	192	–8.52	0.78	–1.88	–0.23	–0.07	0	–0.60	0.85	0.44	Significant	Increase
Property-damage-only multiple-vehicle crashes												
3SG	126										No model found	
3ST	141										No model found	
4SG	176										No model found	
4ST	192	–6.77	0.68	–1.90	–0.59	–0.44	0	–0.33	0.71	0.46	Significant	Increase

NOTE: Coefficients are used in the model form shown in Equation (6).

learned about the interactions between motor vehicles and bicycles on streets with narrower lanes, lane widths less than 3.6 m (12 ft) should be used cautiously where substantial volumes of bicyclists share the road with motor vehicles, unless an alternative facility for bicycles such as a wider curb lane or paved shoulder is provided.

Lane Widths on Arterial Intersection Approaches

Analysis of geometric design, traffic volume, and accident data collected in NCHRP Project 17-26 has found that, with limited exceptions, there is no consistent, statistically significant relationship between lane width and safety for approaches to intersections on urban and suburban arterials. There is no indication that the use of 3.0- or 3.3-m (10- or 11-ft lanes), rather than 3.6-m (12-ft) lanes, for arterial intersection approaches leads to increases in accident frequency. There are situations in which use of narrower lanes may provide benefits in traffic operations, pedestrian safety, and/or reduced interference with surrounding development, and may provide space for geometric features that enhance safety such as medians or turn lanes. The analysis results indicate narrow lanes can generally be used to obtain these benefits without compromising safety.

Two caveats should be noted. First, the data for one of the states analyzed showed an increase in crash rates for approaches to four-leg STOP-controlled intersections with lane widths of 3.0 m (10 ft) or less; however, just the opposite was found in the other state. While the findings are not fully consistent, they suggest that lane widths of 3.0 m (10 ft) or less on approaches to four-leg STOP-controlled intersections should be used cautiously unless local experience indicates otherwise. Second, as noted above, lane widths less than 3.6 m (12 ft) should be used cautiously where substantial volumes of bicyclists share the road with motor vehicles, unless an alternative facility for bicycles such as a wider curb lane or paved shoulder is provided.

CONCLUSIONS AND RECOMMENDATIONS

A safety evaluation of lane widths for arterial roadway segments found no indication, except in limited cases, that the use of narrower lanes increases crash frequencies. The lane width effects in the analyses conducted were generally either not statistically significant or indicated that narrower lanes were associated with lower rather than higher crash frequencies. There were limited exceptions to this general finding. It was found that crash frequency in one state was higher for 3.0 m (10 ft) lanes than for 3.3 and 3.6 m (11 and 12 ft) lanes on four-lane undivided arterials and was higher in the other state for 2.7 m (9 ft) lanes that for 3.0 m (10 ft) lanes on four-lane divided arterials. However, neither of these statistically significant effects observed in one state were statistically significant in the other state.

Similarly, a safety evaluation of lane widths for arterial intersection approaches found no indication, except in limited cases, that the use of narrower lanes increases crash frequencies. The lane width effects in the analyses conducted were generally either not statistically significant or inconsistent. With only one limited exception, there is no indication that the use of lanes narrower than 3.6 m (12 ft) on intersection approaches leads to increases in crash frequency. The data for one state showed higher crash frequencies for approaches to four-leg STOP-controlled intersections, for approaches with 3.0 m (10 ft) lanes than for approaches with 3.6 m (12 ft) lanes; however, just the opposite was found in data from the other state.

It is concluded from this research that there is no indication that crash frequencies increase as lane width decreases for arterial roadway segments or arterial intersection approaches.

These findings suggest that the AASHTO *Green Book* is correct in providing substantial flexibility for use of lane widths narrower than 3.6 m (12 ft) on urban and suburban arterials. Use of narrower lanes in appropriate locations can provide other benefits to users and the surrounding community including shorter pedestrian crossing distances and space for additional through lanes, auxiliary and turning lanes, bicycle lanes, buffer areas between travel lanes and sidewalks, and placement of roadside hardware. Interpretation of design policies as rigidly requiring the use of 3.6 m (12 ft) lanes on urban and suburban arterials may miss the opportunity for these other benefits without any documentable gain in safety.

The research found three situations in which the observed lane width effect was inconsistent—increasing crash frequency with decreasing lane width in one state and the opposite effect in another state. These three situations are:

- lane widths of 3.0 m (10 ft) or less on four-lane undivided arterials.
- lane widths of 2.7 m (9 ft) or less on four-lane divided arterials.
- lane width of 3.0 m (10 ft) or less on approaches to four-leg STOP-controlled arterial intersections.

Because of the inconsistent findings mentioned above, it should not be inferred that the use of narrower lane must be avoided in these situations. Rather, it is recommended that narrower lane widths be used cautiously in these situations unless local experience indicates otherwise.

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