Residential Street Typology and Injury Accident Frequency

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ABSTRACT

Communities all across the U.S. are concerned about the safety of their residential streets. Although this concern is nearly universal, the literature offers few precedents and little information on the relative safety of common residential street typologies. This study offers a method for analyzing the theory that the physical design of streets impacts safety. Through research, systematic observation, and statistical analysis, an attempt was made to identify the safest residential street form with respect to several physical characteristics. These findings expose issues that need to be addressed by practitioners and policy-makers and encourage further study of related topics.

Approximately 20,000 police accident reports from the City of Longmont, Colorado, were reviewed and compared against five criteria for evaluating the probability that street design contributed to the accidents. Once catalogued and entered into a database, each accident location was mapped and described by several physical characteristics. To compare injury accidents per mile per year against other factors, several correlations were explored. The most significant relationship to injury accidents was found to be street width. AS street widths widen, accidents per mile per year increases exponentially, and the safest residential street width are the narrowest (curb face).

I. INTRODUCTION

A fundamental element in the field of planning and urban design is the assumption that narrow streets in a grid pattern are safer than wider streets. Although this theory has been discussed at length by practitioners and academics, little substantive research is available to support this assumption. With the cooperation of the City of Longmont, Colorado, this study was designed to complement the literature by evaluating residential street typology and related injury-accident frequency.

Longmont, Colorado is located approximately 35 miles north of Denver and approximately 15 miles northeast of Boulder. It has experiencing a sustained period of growth as many communities are along Colorado's front range. Longmont has about 19.2 square miles of annexed land and a current population of approximately 72,000.

The rate of urban growth and increasing traffic congestion are the two most often mentioned ills in Longmont, although the quality of new development is rising on this list. Longmont has two developments that are considered to be of the neo-traditional design. These developments with narrow streets, alleys and well-developed street grids give the city staff and residents first hand examples of a design that builds in a higher quality of life. However, the debate over acceptable street widths continues in Longmont as it does in communities throughout the U.S.

II. DATA GATHERING AND MAPPING

The data used in this study were obtained by reviewing approximately 20,000 Longmont accident reports. Each report was examined against several criteria to ascertain that the accident occurred as a result of street typology. Eliminated from the study were accident reports that included the following information;

1. Road conditions that were wet, icy or snow covered

2. Substance abuse - Any notation of the driver being impaired or suspicion of being under the influence of any substance.

3. Traffic volume - accidents which occurred on any street other than a "local". A local street has less than 2,500 Average Daily Traffic (ADT).

The Colorado Department of Transportation has established an inventory of streets in a report entitled "Longmont Street Inventory". This includes an inventory of all the streets in the city with respect to its length, primary surface width, through lane length and other data. The primary surface width and total miles of street were of the greatest interest to this study. Many discrepancies in street width were discovered. Field measurements were conducted to correct the data. These field observations also included evaluation of the other variables in the study.

III. ACCIDENT LOCATION OBSERVATION

Thirteen physical characteristics of each accident location were systematically observed and listed as follows;

	Characteristic	Normative Value
1	Street Curves	Degree of curvature
2	Street width (curb face)	In 2' increments
3	Distance to nearest curb-cut	<20', 21'-50' or >50'
4	Curb type	modified, 6" vertical or none
5	Tree density	Trees per 100 feet within 200 feet of the accident site
6	Traffic control	device distance from accident <20', 21-50', 51-100' or >100'
7	ADT	Ave. annual vehicles per day
8	Sight distance	clear or obstructed view

9	Parking Density	Vehicles per 100 feet parked within 200 feet of the accident site.
10	VMT	Vehicle miles traveled

The ADT of some road segments were not known. In these cases, the ADTs were estimated by identifying the probable travel shed and multiplying the number of houses within this area by 10. Although the use of 10 trips per dwelling unit may be higher than the recognized trip generation rate for attached units, this method allowed for other trips that may have used the street but had neither an origin or destination within the travel shed.

IV. Statistical analysis and correlations

A multiple regression analysis was applied to the data with Kwikstat 4, a windows driven statistical program. The number of accidents per mile per year (a/m/y) was used as the dependant variable in the analysis. The results are presented in Table 1 for the 10 physical characteristics as the independent variables.

The test for those independent variables in Table 1 having a lineal relationship is indicated by a p(2) tail value <0.05. The most statistically significant variable to (a/m/y) was street width (p[2]=0.0000) followed by ADT and VMT.

TABLE 1

KWIKSTAT 4 04-27-2002

Multiple Linear Regression C:\STATS\DBF\RAW2.dbf

Dependent variable is Acc/Mile/Year 10 independent variables, 304 cases.

Variable	Coefficient	St. Error	t-value	p(2 tail)
Intercept	-.9246872	0.2146736	-4.307411	0.0000
Deg. Curvature	-.0024117	0.0016678	-1.446023	0.1492

Variable	Coefficient	St. Error	t-value	p(2 tail)
Deg. Curvature	-.0024117	0.0016678	-1.446023	0.1492
Street Width	0.0387544	0.0044672	8.6752882	**0.0000**
Curb Cut Freq.	-.0062726	0.0118874	-.5276671	0.5981
Curb Type	0.0460912	0.0466812	0.9873608	0.3243
Tree Freq.	-.0148623	0.0282028	-.5269799	0.5986
Traf. Cont. Device	-.0621405	0.0178682	-3.477706	0.0606
ADT	0.2429763	0.0353721	6.8691462	**0.0000**
Sight Dist.	-.0382670	0.0477721	-.8010330	0.4238
Parking Density	-.0369261	0.0330313	-1.117913	0.2645
VMT	-.0000056	5.7D-07	-9.819408	**0.0000**

Source	Sum of Sqs	df	Mean Sq	F	p-value
Regression	56.697728	10	5.6697728	33.214030	0.0000
Error	50.016316	293	0.1707042		
Total	106.71404	303			

A thorough treatment of the data was conducted by applying quadratic, parabolic, power and exponential regression analysis to the data for street widths of 14 to 50 feet vs. A/m/y with the following results;

$$y=0.0014e^{(0.1323x)}$$

Where;

Y = Accidents per mile per year
X = Street width (curb face) in feet

The corrected R^2 value is 0.73.

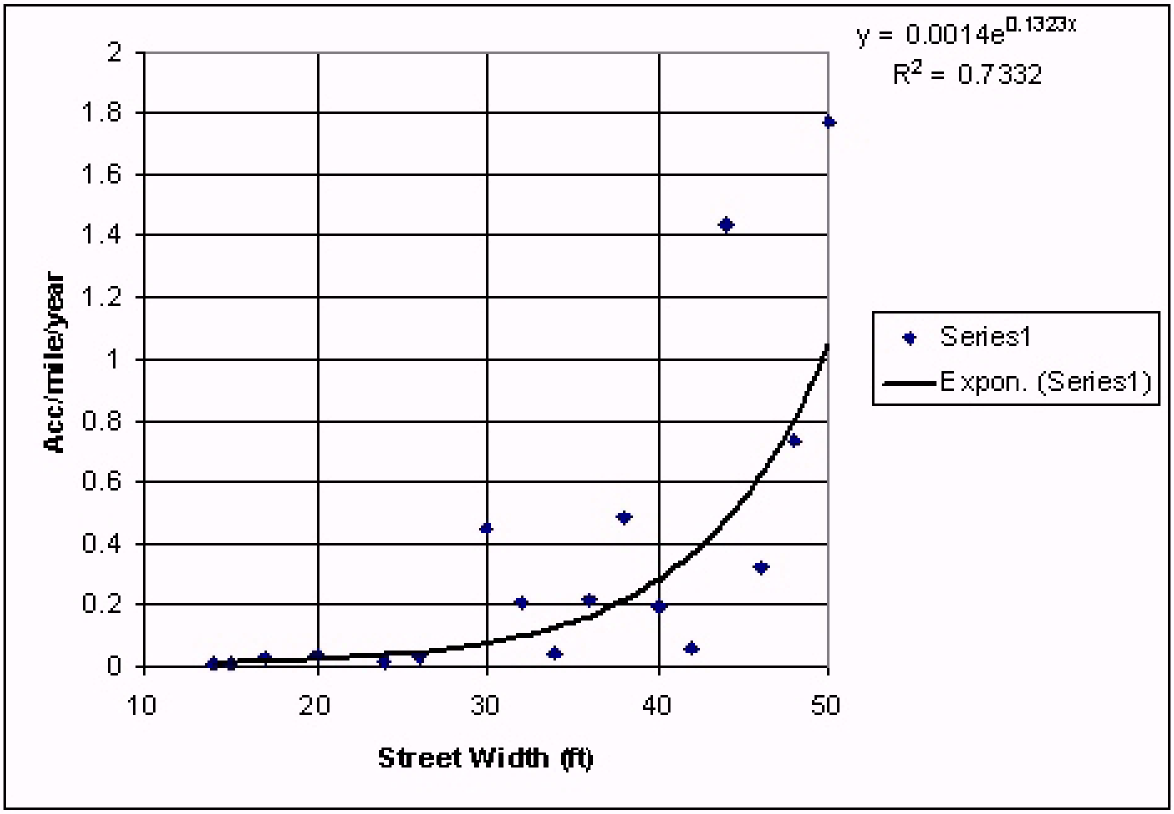
The data for the development of the regression curve and Figure 1 are provided in table 2.

TABLE 2

Street Width	a/m/y	Regression a/m/y
14	0.006	0.01
15	0.006	0.01
17	0.029	0.01
20	0.034	0.02
24	0.011	0.03
26	0.029	0.04
30	0.45	0.07
32	0.203	0.10
34	0.04	0.12
36	0.213	0.16
38	0.481	0.21
40	0.194	0.27
42	0.057	0.36
44	1.441	0.46
46	0.317	0.60
48	0.731	0.79
50	1.775	1.02

Using this regression equation, a typical 36-foot wide residential street has 0.16 (a/m/y) as opposed to 0.03 for a 24 foot wide street. This difference is about a 487 percent increase in accident rates. The data suggests that the wider the street, the greater the accident rate (see Figure 1, below).

Figure 1



The statistical data also suggests that there is a linear relationship between a/m/y and both ADT and VMT. A regression analysis of those data is somewhat conflicting, however. The ADT data depicted in Figure 2, with a low R^2 value of 0.17, has a best fit with a 5^{th} order polynomial but is irregular, at best. It appears that the accident rate increases with ADT to about 1,000 ADT, then decreases.

Figure 2

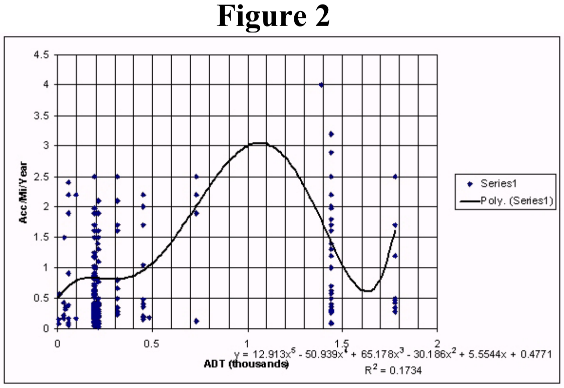
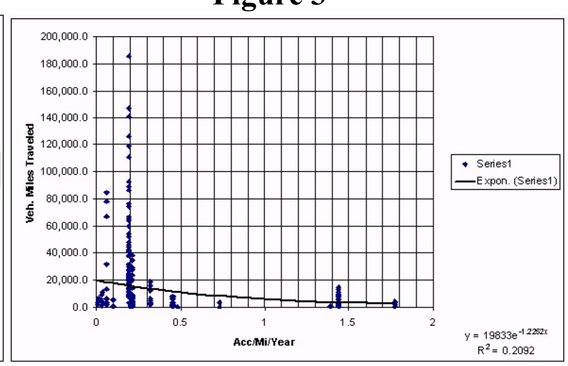
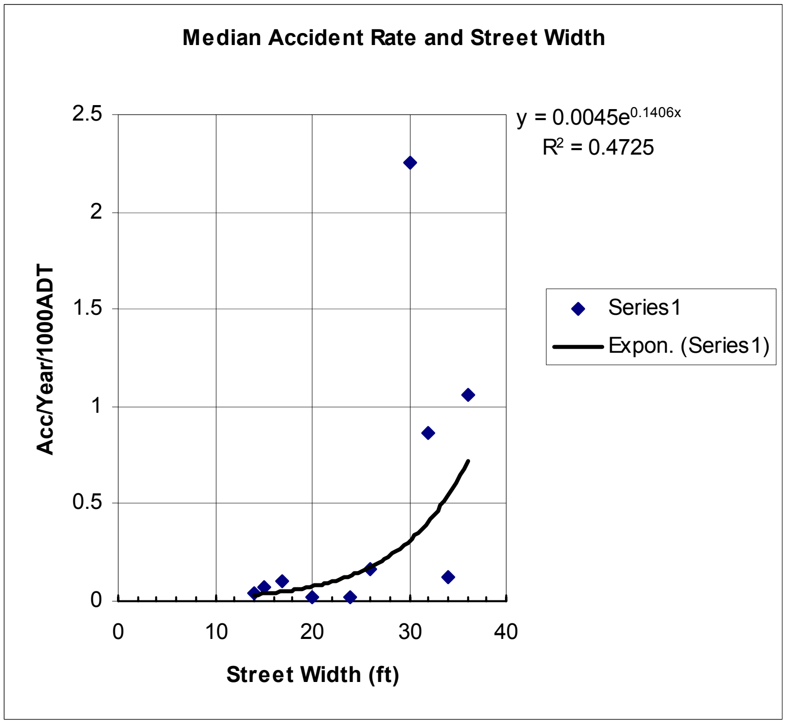


Figure 3



The VMT data (Figure 3) also has a low R^2 of 0.21 and suggests that accident rates decrease with vehicle miles traveled. Although there seems to be a correlation of volumes and vehicle miles traveled, the results are unclear with rather weak correlations. A regression exercise was then run for accidents/year/1000/VMT to determine if there was significance to street width. The r2 values were not significant for data sets greater than 36 feet of street width. There was significance detected for streets 36 feet in width and less as shown in the following Figure 4;



For up to 71 data points, the R^2 limit was 0.330. The R^2 value of 0.4725 is, therefore, statistically significant. This result correlates with the earlier observation that there is a significant increase in injury accident rates for residential streets up to 36 feet in width. It would be safe to assume that this trend continues for wider streets.

The authors then explored emergency response activity with regard to fire access and street width. An evaluation of structure fire incidents revealed that there were two that occurred in the study period. The first was in a fairly new subdivision with a street width of 36 feet and the second was in the older part of town having a street width of 24 feet and a rear alley (20' right-of-way, 12' paved surface). An interview with the Fire Chief indicated that there was not a problem with access to either incident and response times were adequate. The attack strategy for the second incident included access from the alley and it was viewed as an advantage to have a second point of access in a narrow street environment. Additionally, there were no problems directing the ladder truck to the alley as part of the defense strategy.

V. CONCLUSION

Clear relationships are evident between accident frequency and street width. The findings support the premise that narrower, so called "skinny" streets, are safer than standard width local streets.

A larger question of public safety concerns fire apparatus and emergency vehicle access with narrow streets. The service reports from the Fire Department of the City of Longmont were evaluated for the study period. No fire related injuries or accidents occurred during the eight-year period of the study. Additionally, there were no access or response time problems reported.

Lastly, additional research is encouraged to verify these results. In a very limited search of the literature, three studies were noted. In the first report, the mean free speed of cars in suburban roads increases linearly with the roadway width, particularly between 17 and 37 feet[2]. The second paper by Giese, et al, suggests that spatial enclosure, sight distance and [width] constriction techniques influence vehicle speeds[3]. More fully, vehicle speeds decrease with width constriction. The third study indicates that building enclosure reduces vehicular speeds[4]. This supports the conclusion of this study that narrower streets are safer.

It is notable that there were several physical elements that do not affect accident rates; parking and tree density. These are also debated design elements in narrow street environments.

Finally, it is the conclusion of the authors that, because of the fire access needs, narrow streets should not be used without at least a second means of access. This can be accomplished with alleys and/or an interconnected network of streets.

END

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[2] Farouki, Omar, and William Nixon. 1976. The Effect of the Width of Suburban Roads on the Mean Free Speed of Cars. Traffic Engineering and Control 17,2: 508-9

[3] Giese, Joni L., Gary A. Davis and Robert D. Sykes, The relationship between residential street design and pedestrian safety, Institute of Transportation Engineers Compendium of Technical Papers on CD-ROM. August, 1997.

[4] Smith, D. T. and Donald Appleyard, Improving the Residential Street Environment-Final Report, Federal Highway Administration, Washington D. C., 1981, p. 127