Evaluating The Interactive Effects of Traffic Volumes and Access Density On Crash Frequency

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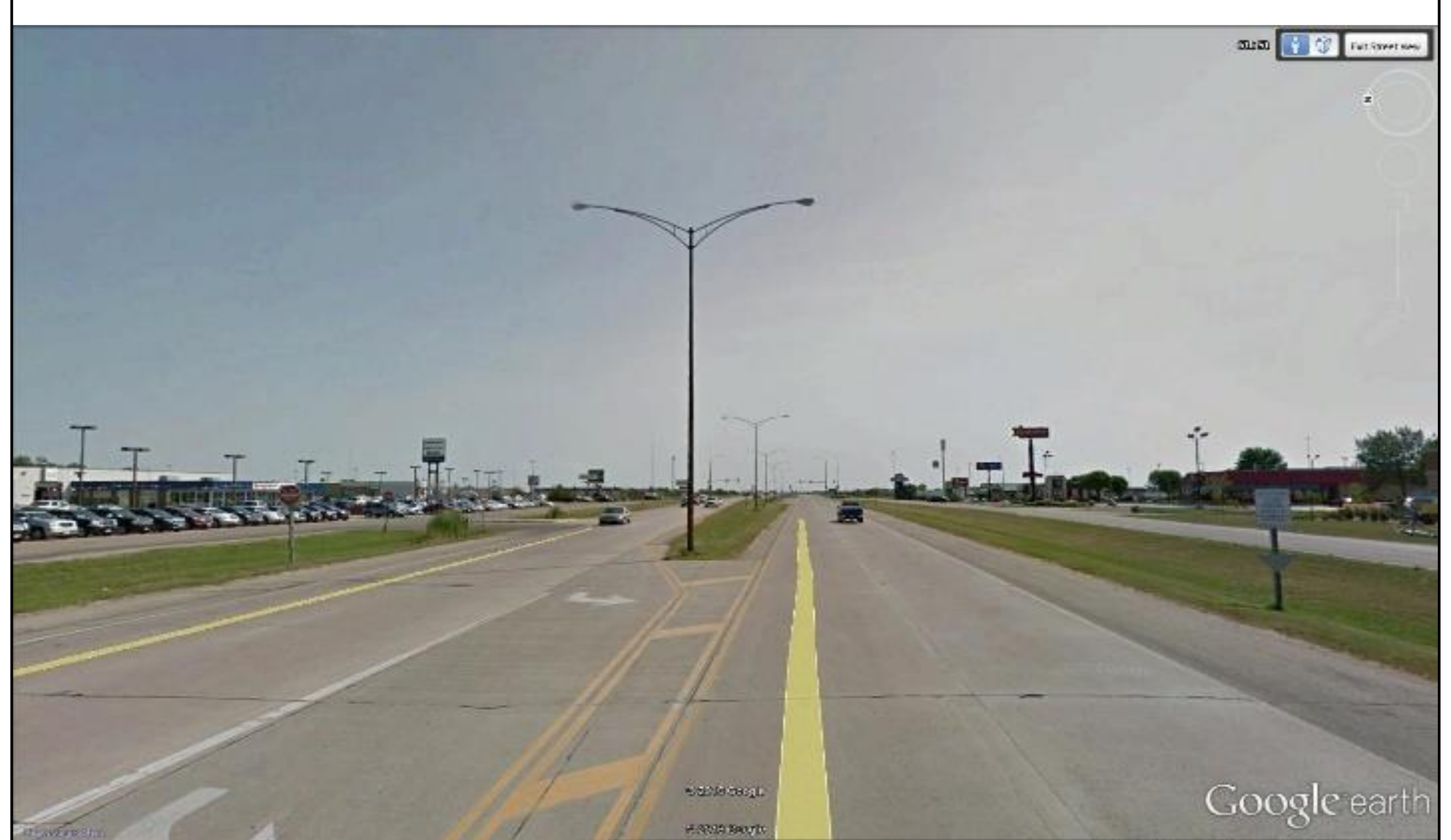
Introduction

Transportation access management is defined as systematic control of the design, spacing, operation, and locations of street connections, interchanges, driveways, and median openings on the roadway with the purpose of providing vehicular access while preserving the efficiency and safety of the transportation system. Access management is a proven method for maintaining and improving roadway capacity; traffic flow; and the safety of traffic, pedestrians, and bicyclists on rural and urban highways and streets. Research has shown that access management related improvements to traffic operations and safety have a positive impact on the local economy.

One of the most basic access management methods is controlling access density. This can be accomplished by:

1. managing access to/egress from driveways,
2. using of frontage roads,
3. requiring driveways to access side roads or allies, and
4. using combined driveways.

These methods can be applied in both urban and rural settings. The figures below are Google Earth images of access management (i.e., use for a depressed grass median and frontage roads and the use of alley access to garages and driveways) in Brookings, SD.



Depressed Grass Median and Frontage Roads on Highway 14 Near I-29 in Brookings, SD (Street View)

Alley Access to Garages and Driveways to Reduce Access Points on 9th St. near SDSU in Brookings, SD (Street View)

Background and Objectives

CMFs from the *CMF Clearinghouse* include the following treatments related to driveway density:

1. Closure or relocation of all driveways from the functional area of an intersection (CMFs of 0.93-1.17 for total crashes and 1.41-1.67 for fatal and injury crashes, with one-star quality ratings) , and
2. Modifying access point density (a function of access point density and traffic volume, the quality is typically unrated).

The majority of CMFs available in the *CMF Clearinghouse* for predicting changes in safety related to driveway density are of low quality or are unrated.

The objectives of this research are to evaluate whether the safety impacts (in terms of CMFs) of driveway access density vary as a function of traffic volumes (i.e., AADT) on urban streets (using interactions between access density and traffic volume). This includes the analysis of urban principal arterials, urban minor arterials, and urban collectors. The results of the CMF with traffic volume interactions are compared to CMFs without the interactions.

Methods

Random parameters negative binomial regression was used to develop regression models that incorporated different relationships between traffic volume and access density. The random parameters negative binomial is estimated using:

$$LL = \sum_{\forall i} \ln \int_{\varphi_i} g(\varphi_i) P(n_i \mid \varphi_i) d\varphi_i$$

Where

φ_i = the random distribution for coefficient i;

$g()$ = the probability density function of φ_i; and

$P(n_i \mid \varphi_i)$ = the probability density function for the negative binomial.

The random parameters negative binomial regression models in this research were estimated using the Nlogit 6 software. 200 Halton draws were used in each of the evaluations. Correlated random parameters were used to account for correlations between the estimated random parameters.

Various functional forms were evaluated for AADT, as well as interactions with access density. These include:

1. Power function for AADT (i.e., $AADT^{\beta}$)
2. Hoerl function for AADT (i.e., $AADT^{\beta} \exp(\beta_2 AADT)$)
3. Modified Heorl function for AADT (i.e., $AADT^{\beta} \exp(1/(\beta_2 AADT))$)

Plots of standardized residuals, based on predictions using the random parameter estimates, were used to evaluate the best functional forms. Regression models were developed for total crashes.

Data

HSIS data for Minnesota for the years 2009-2014 were used in the analysis. The original HSIS data do not have access density. Thus, 406 road segments (two-lane undivided urban arterials and collectors) were randomly selected for including in the analysis. Google Earth was used to determine the number of access points and horizontal curves within each of the segments. Descriptive statistics and definitions for the variables used in the analysis are shown below.

Variable	Definition	Mean	Std. Dev.	Min	Max
AADT	Annual Average Daily Traffic	4456.914	5193.408	64	32310
Length	Length (miles)	0.279	0.197	0.010	0.997
Principle Arterial	1 = Principle Arterial, 0 = Otherwise	0.160	0.367	0	1
Minor Arterial	1 = Minor Arterial, 0 = Otherwise	0.189	0.391	0	1
Access Density	Number of Access Points per Mile	45.397	31.955	1.370	146.154
Shoulder Width	Shoulder Width(ft)	2.233	3.499	0	22
Hor. Curve Density	Number of Horizontal Curves per Mile	1.898	5.919	0	100
Total Crashes	Total Crashes per Year	1.161	2.358	0	25

Results

The analysis results indicated that:

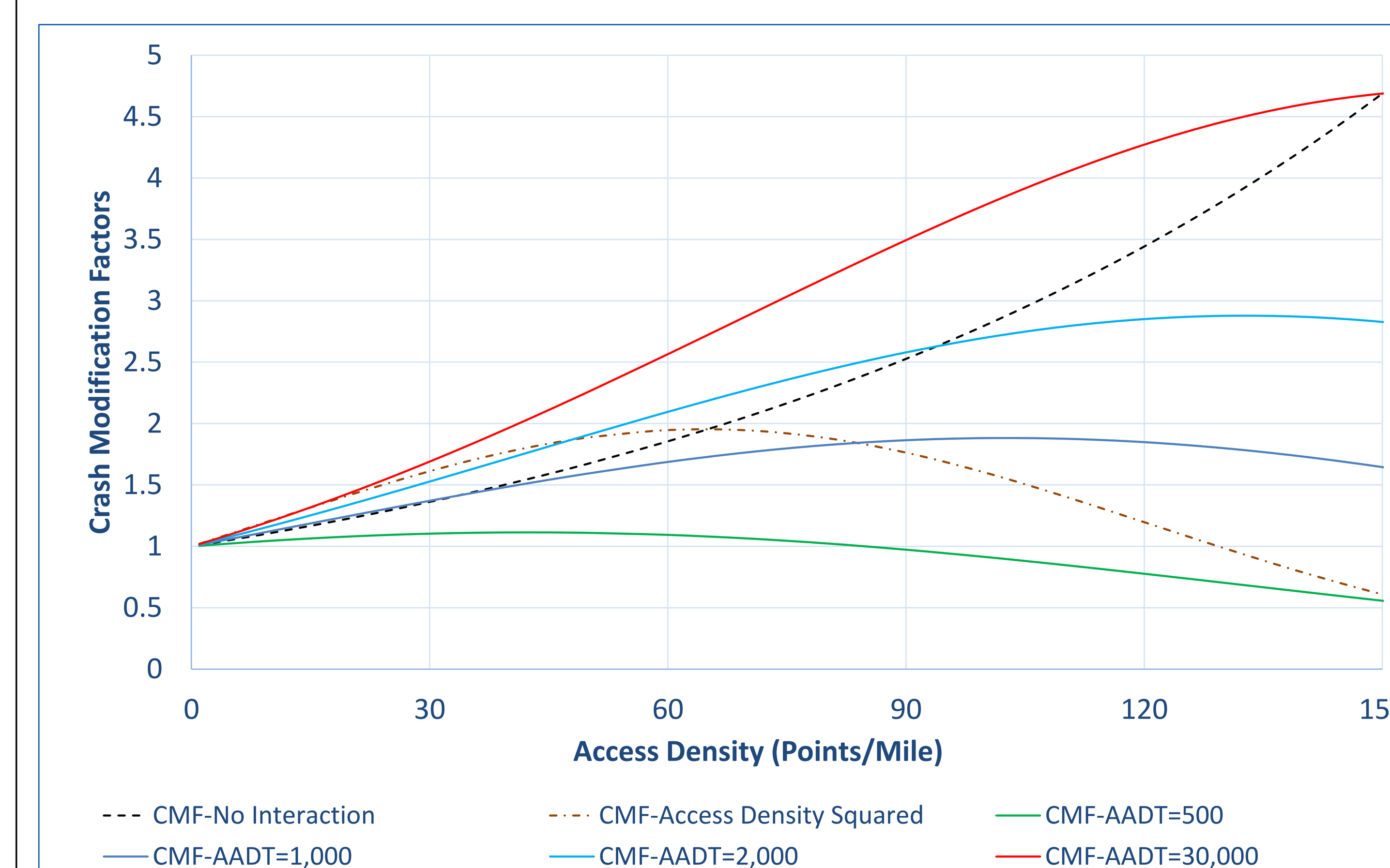
1. Both access density and access density squared should be included in the CMFs,
2. The modified Hoerl function provided the best fit (determined using residual plots, AIC, BIC, etc.),
3. The interaction between access density and AADT was highly significant (p-value < 0.0001), and
4. The best interaction between access density and AADT was access density divided by AADT.

The CMFs for regression models with access density only, access density squared, and the interaction term are provided below. The figure shows the differences between these CMFs.

$$CMF = e^{0.0196 Access\_Density - 0.00006 Access\_Density^2 - \frac{7.22 Access\_Density}{AADT}}$$

$$CMF = e^{0.0207 Access\_Density - 0.00016 Access\_Density^2}$$

$$CMF = e^{0.0103 Access\_Density}$$



Conclusions

Multiple CMFs were developed for access density on two-lane urban arterials and collectors using data from Minnesota. Random parameters negative binomial regression was used in developing the CMFs. Based on residual plots, AIC, BIC, and other statistical tests, it was determined that the best CMF for the data used included access density, access density squared, and access density divided by AADT.

Future work should use data from multiple states as well as larger sample sizes to develop CMFs for access density. The results from these analyses should assess the different CMF structures used in this research to validate these findings or determine if there is a more appropriate functional form. This should also be done for rural roads and other urban roadway types.

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