Investigating the Impact of Road Cross-Section Elements on Crash Occurrence in Urban Areas

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Event Number: 1327
Presentation Number: TRBAM-21-00755
Wed 1/27/2021 at 4:00 PM- 5:30 PM ET

Background & Problem

The roadway cross-section design has an impact on key operational characteristics such as safety, capacity and function of the desired facility.

Evaluation of the capacity and consideration of the roadway function in association with the cross-section design are relatively easy.

On the other hand, evaluation of the safety implications of cross-section design requires an extra effort.

Studies on this subject have shown inconsistent and, in some cases, contradictory conclusions.

Moreover, many studies have focused on rural highways and urban freeways while a very few have considered the urban roads.

Besides, another important and highly debated related subject (in transportation and urban design studies) is the presence of on-street parking in the urban areas and their safety implications.

Objective

To examine the impact of road cross-sectional elements and on-street parking on crash occurrence in urban areas by developing road segments' safety performance functions (SPFs).

The cross-section and parking variables included in the study were:

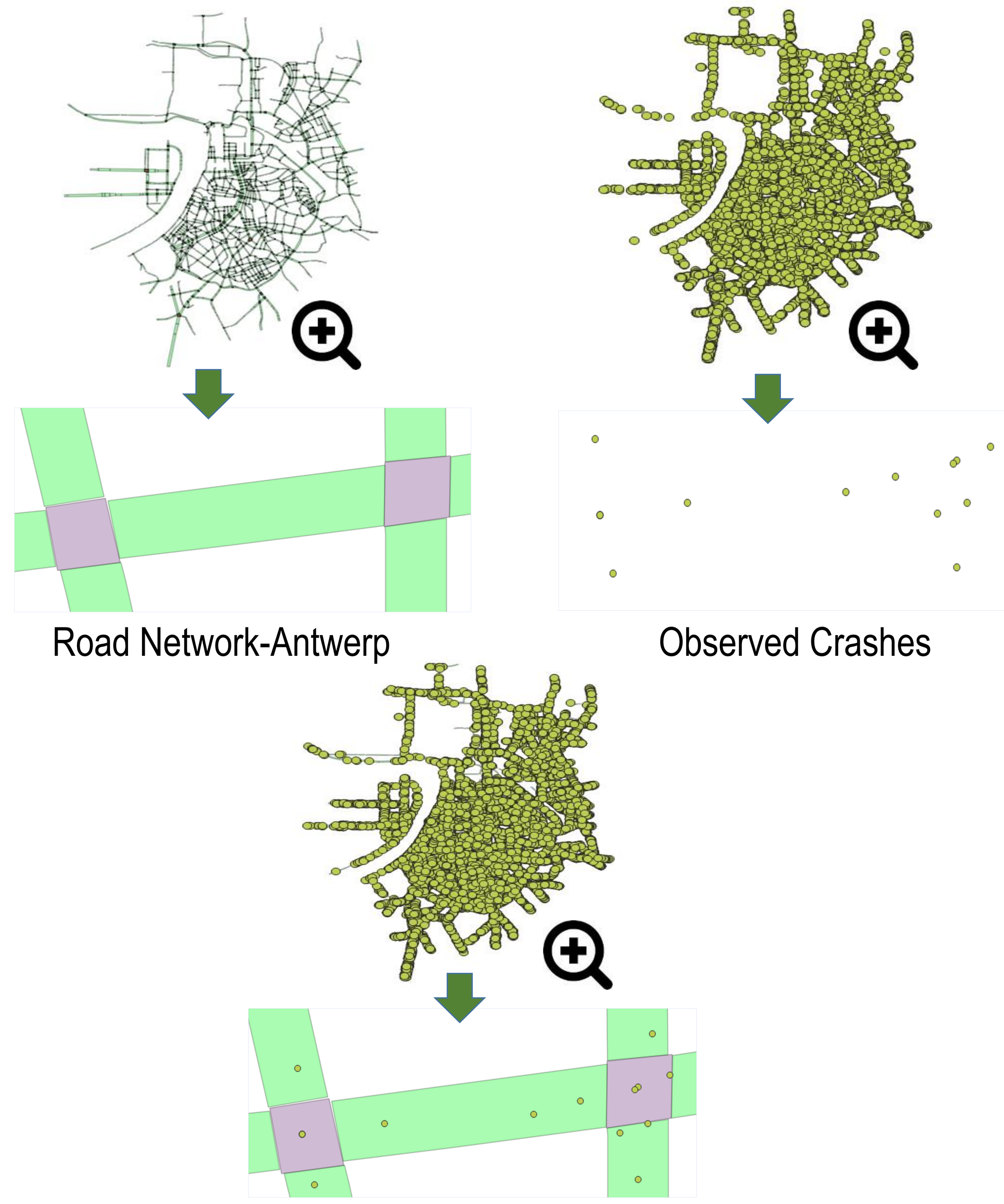
1. Number of lanes
2. Lane width
3. Parking variables
   1. Parking arrangement
   2. Parking type

Materials and Methods

A data set was prepared for the estimation of the SPFs. It consisted of

1. Six (2010-2015) years of crash data
   1. Source: Antwerp Police
   2. Divided into road segment and intersection crash
   3. Informs about different crash severities, e.g., all crashes, fatal & injury crashes, injury crashes and PDO crashes
2. Road data
   1. Source: Road register of the Flemish government
   2. Provides the lane width, number of lanes, segment IDs
3. Traffic data
   1. Source: Lantis (Antwerp-based mobility management company)
   2. Consists of actual traffic counts and model generated counts

Data Processing



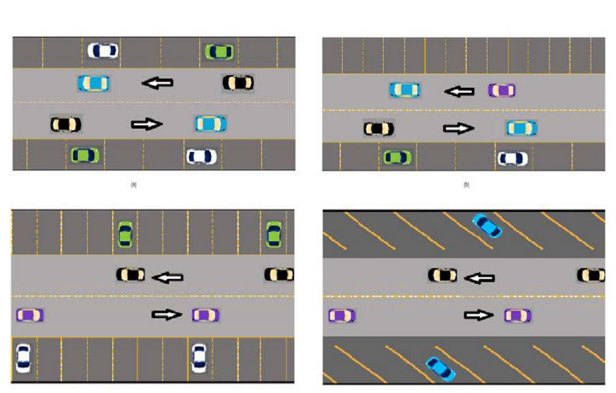
Road Network-Antwerp

Observed Crashes

Crashes on the Network

Variables

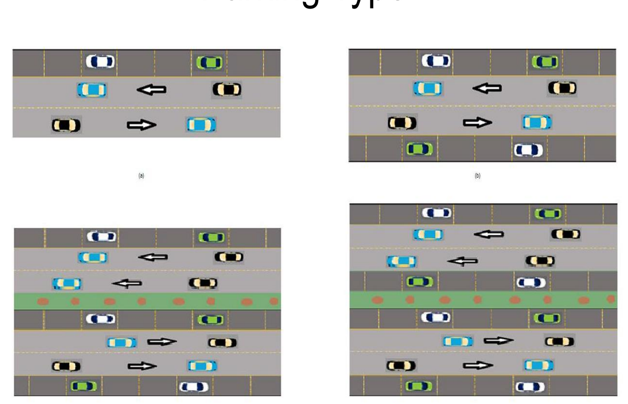
- Traffic Volume (AADT: Vehicle/day)
- Length of segments (km), lane width (m), number of lanes (1,2,…n), Parking type, and Parking arrangement
- Crash frequency



Parking Type

Parking Type

1. Parallel
2. Mixed
3. Perpendicular — Others
4. Angle — Others



Parking Arrangement

Parking Arrangement

1. One-sided
2. Two-sided
3. Three-sided(divided) — Others
4. Four-sided(divided) — Others

268.80 km of urban roads

2467 homogeneous road segments

Statistical Analysis

General Model: $\hat{E}\{\mu\} = f(X_1 X_2 X_3 \ldots\ldots \; \beta_0, \beta_1, \beta_2 \ldots\ldots)$

Negative Binomial Distribution:

$$\mu_i = exp(\beta X_i + \varepsilon_i)$$

$$Prob[y_i|\mu_i] = \frac{\Gamma\left[\left(\frac{1}{k}\right) + y_i\right]}{\Gamma\left(\frac{1}{k}\right) y_i!} \left[\frac{\frac{1}{k}}{\left(\frac{1}{k}\right) + \mu_i}\right]^{\frac{1}{k}} \left[\frac{\mu_i}{\left(\frac{1}{k}\right) + \mu_i}\right]^{y_i}$$

Model Structure:

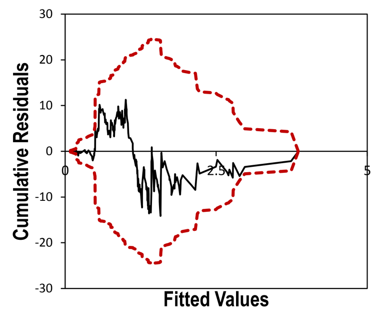
$$\mu_i = exp\,(\beta_0 + \beta_{1.} L_i + \beta_2 . ln(AADT_i) + \cdots + \beta_k . (X_{ki}))$$

Measures of Statistical Accuracy

Mean Prediction Bias (MPB)= $\frac{\sum_i \left(\frac{obs_i}{yi} - \frac{pred_i}{yi}\right)}{n}$

Mean Squared error(MSE)= $\frac{\sum_i \left(\frac{obs_i}{yi} - \frac{pred_i}{yi}\right)^2}{n - m_2}$

Mean absolute Deviation(MAD)= $\frac{\sum_i \left|\frac{obs_i}{yi} - \frac{pred_i}{yi}\right|}{n}$



CURE Deviation Analysis:

%age of the data points outside the CURE plots

Validation factor: $\frac{Predicted\ crashes}{Observed\ crashes}$

Results

Variables		All crashes Coef.	PDO Coef.	Injury & Fatal Coef.	Injury Coef.
Intercept		-0.847**	-0.666**	-3.900**	-3.954**
Length		2.314**	2.434**	2.506**	2.080**
ln(AADT)		0.270**	0.203**	0.547**	0.551**
No of Lanes		0.051**	0.061**	0.052**	0.037
Lane width		-0.043	-0.054	-0.157**	-0.107
Parking Type					
Base: No Parking	Others	0.169	1.123*	-1.454*	-1.293
	Parallel	0.314	1.110*	-1.236*	-1.185
Parking Arrangement					
Base: No Parking	Others	0.812	-0.034	1.884**	1.673**
	2-sided parking	0.390	-0.318	1.460*	1.372**
	1-sided parking	0.115	-0.660	1.406*	1.297**
Dispersion		0.646	0.670	0.755	0.769
Log-likelihood		-4946.370	-4528.728	-2766.602	-2821.160
AIC		9914.740	9079.457	5555.203	5664.320

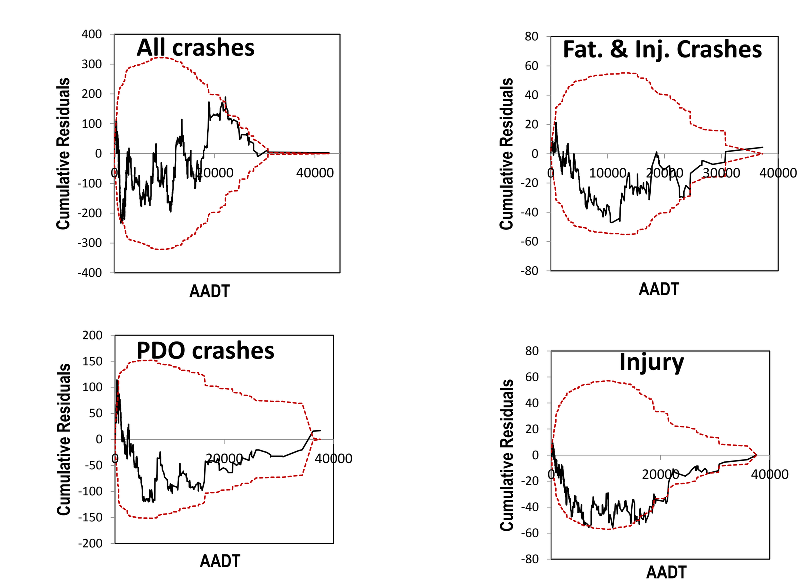
**** significant at 95%, * significant at 90%**

Results

1. The traffic volume (AADT) and segment length were positively associated with the expected crash frequency in all models.
2. The number of lanes variable was positively associated with crash frequency in all models except "injury crashes".
3. Lane width was not significant except for "injury & fatal crashes" model where a negative association was found.
4. Parking type was not significant for "all" and "injury crashes" but significant for "PDO crashes" and "injury & fatal crashes".
5. Parking arrangement was not significant for "all" and "PDO crashes" but significant for "injury crashes" and "injury & fatal crashes".

Validation & GOF Measures

Measures	All	PDO	Injury & Fatal	Injury
MPB	-0.076	0.052	0.024	0.014
MAD	0.795	0.633	0.290	0.290
MSPE	1.584	1.140	0.379	0.512
% CURE Deviation	1%	10%	0%	3%
Validation Ratio	0.942	1.060	1.075	1.044



Takeaways

1. Minimizing the number of lanes could results in a reduction of all crashes, irrespective of the severity.
2. Increasing lane width could potentially reduce the frequency of high severity crashes including fatal crashes in the urban areas.
3. On-street parking should be carefully provided on urban roads. Perpendicular and angled parking types could relatively reduce injury and fatal crashes compared to parallel parking.
4. Parking on one side of a roadway segment is safer compared to two sides. Parking on both sides of each direction of divided roadways is the most dangerous one and should be avoided, if possible.

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