Understanding the Spatio-Temporal Patterns of Pedestrian Crashes Along the Urbanization Gradient

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Outline

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- Data
- Method
- Results
- Discussions

Introduction

Studies indicate that **urbanization increases** lead to

- **increase** in impervious surface,
- **increase** in environmental failures,
- **increase** in traffic accidents, and
- **decrease** in pedestrian safety.

Therefore, along the urbanization gradient of a city, it is essential to

- investigate the spatial and temporal patterns of pedestrian crashes, and
- identify crash factors.

Research Questions

1. How does number of pedestrian crashes change along the urbanization gradient from the CBD of a city?
2. How is number of pedestrian crashes related to the degree of urbanization, which is characterized by proportion of impervious surface, along the urbanization gradient of a city?
3. How is crash severity influenced by different crash factors along the urbanization gradient of a city?

Research Objectives

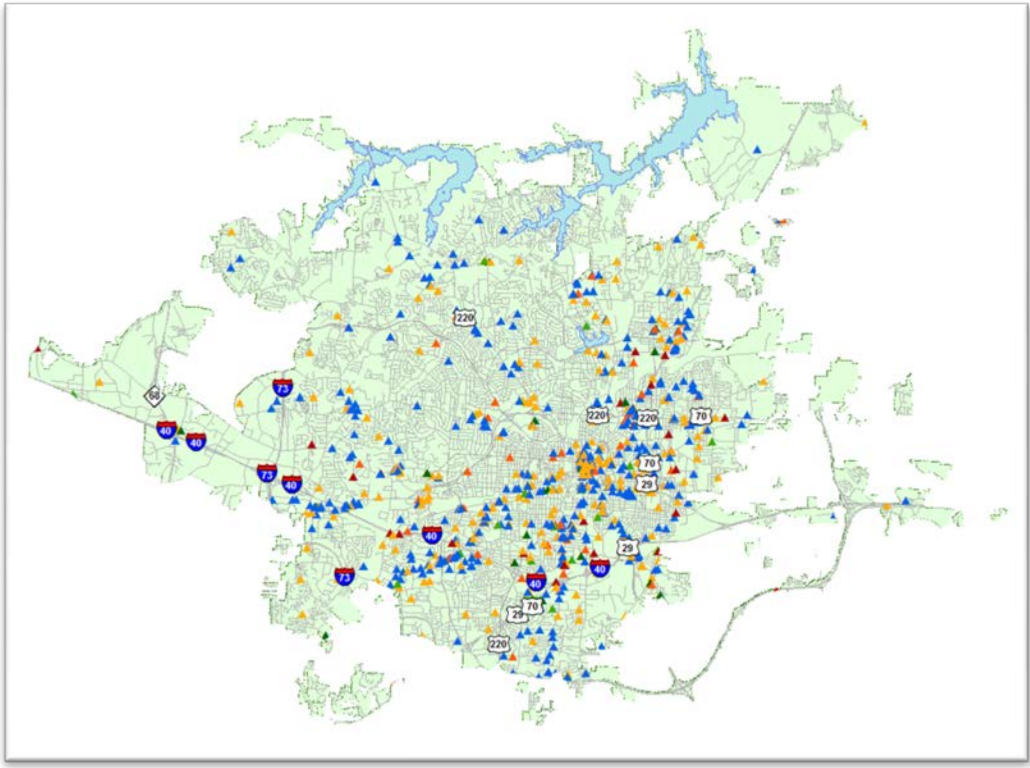
1. Investigate the spatial and temporal patterns of pedestrian crash frequency along the urbanization gradient of the City of Greensboro;
2. Identify factors related to crash severity along the urbanization gradient of the City of Greensboro.

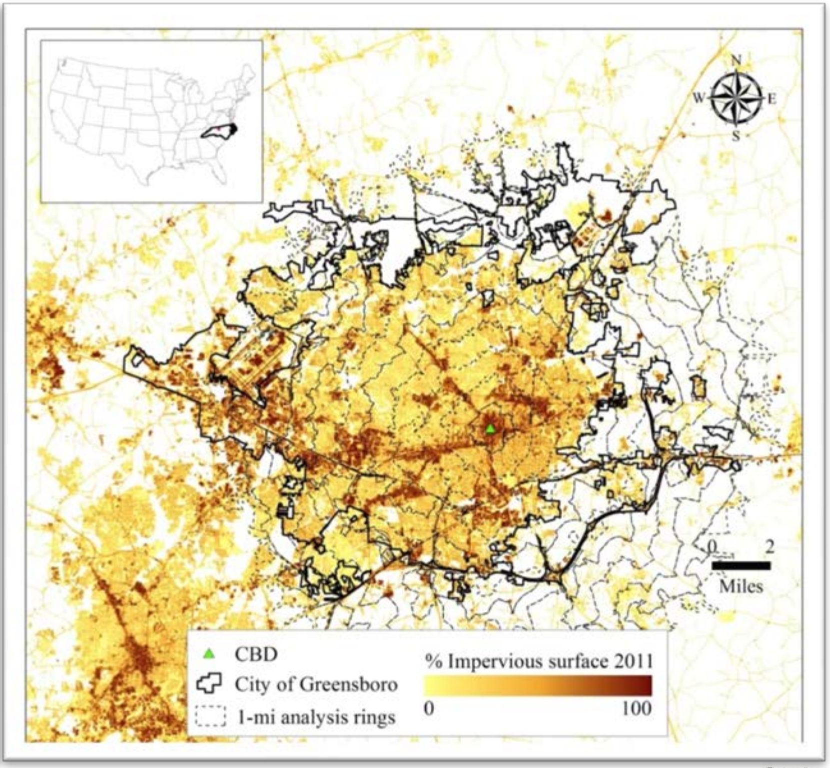
Research Benefits

1. Evaluate the urbanization of a city in the context of pedestrian safety;
2. Improve pedestrian safety along corridors to/from the CBD.

Data

- NCDOT pedestrian crash vector dataset (2007-2012)
- GDOT street network vector dataset
- National Land Cover Database 2011 - Percent Developed Imperviousness raster dataset

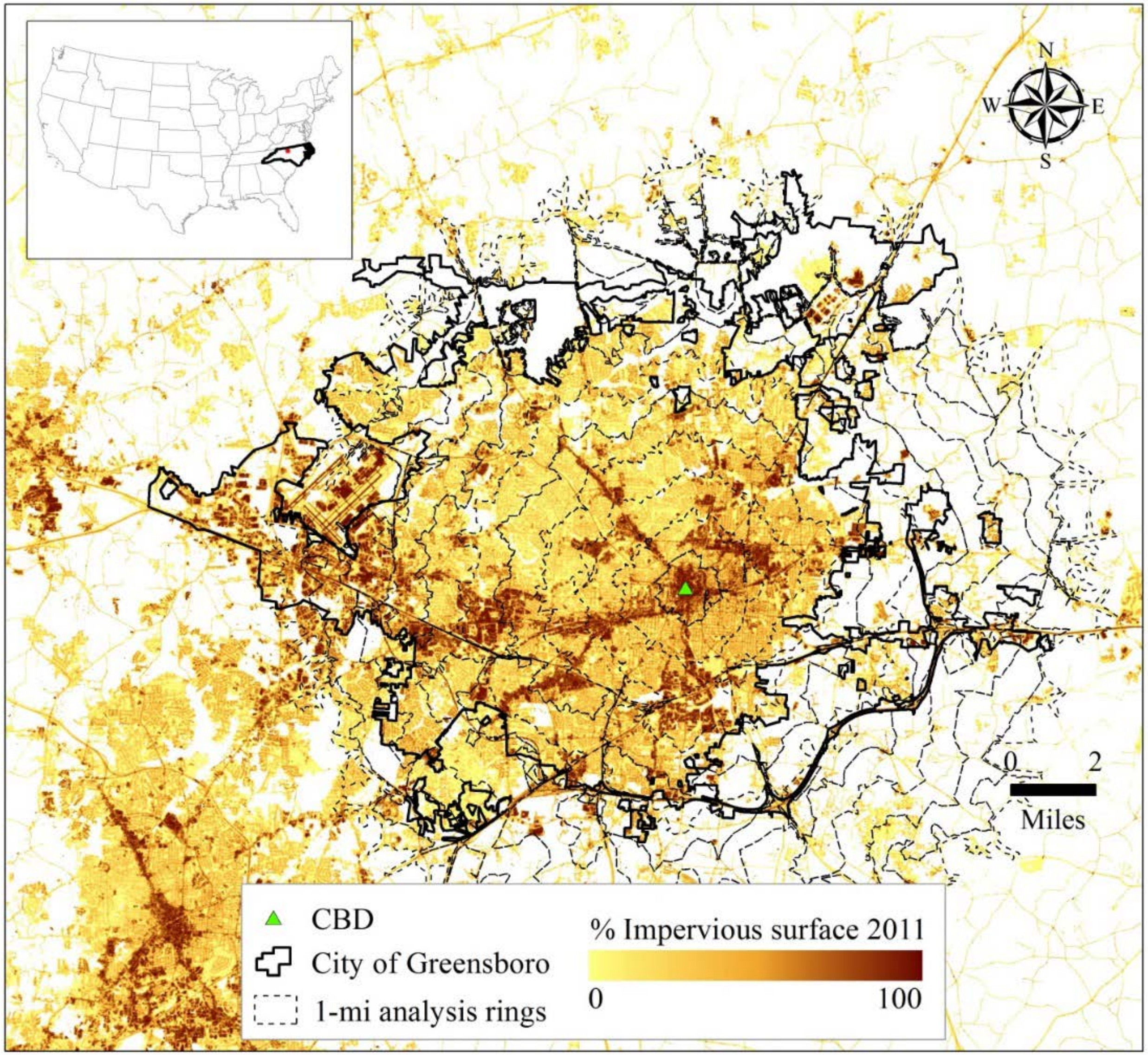




Methods

1. **Characterizing urbanization gradient by 1-mile rings around the CBD**

- Network Analyst used to create 11 rings
- Ring width = 1 mile



Methods (cont.)

2. Spatial pattern analysis

- Correlation analysis conducted for 11 rings
- Variables
- number of pedestrian crashes (regardless of crash years and severity)
- % impervious surface, an indicator of degree of urbanization

Methods (cont.)

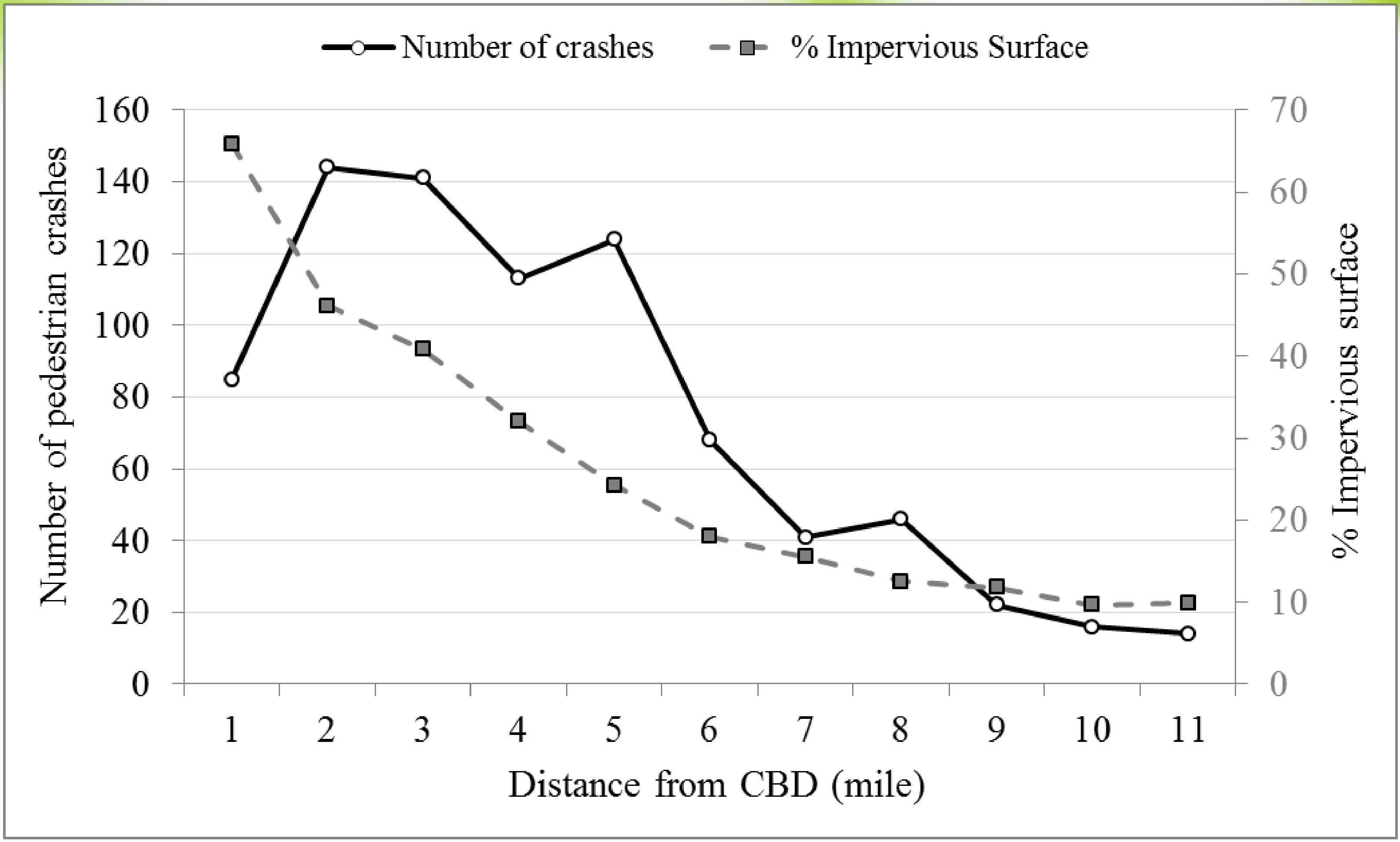
3. Temporal pattern analysis

- Spider plots used to visualize numbers of pedestrian crashes in 24 hours for each analysis ring.

4. Crash severity modeling

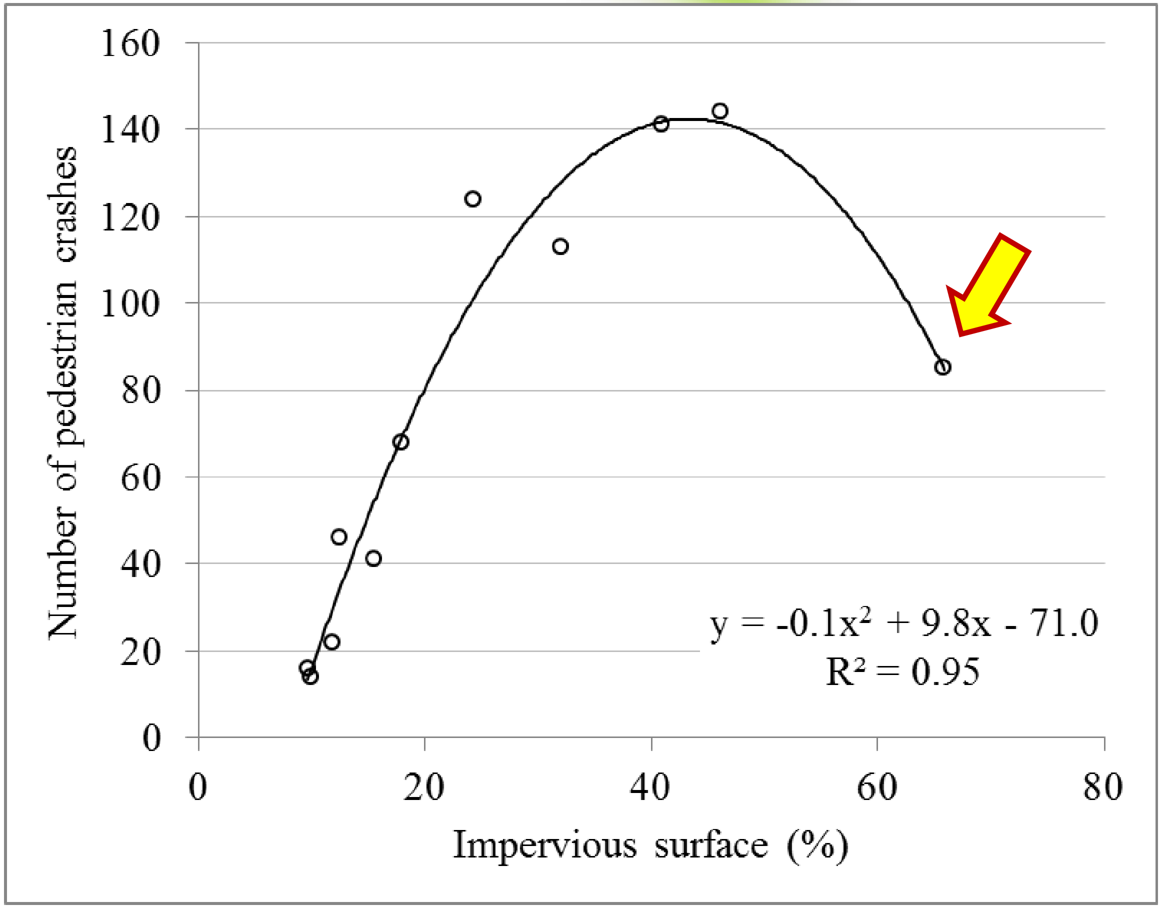
- Ordered probit regression models used to identify factors of crash severity for each analysis ring
- Dependent variables: crash severity (No Injury, Possible Injury, Evident Injury, Disabling Injury, and Fatality)

Results – Spatial Pattern of Pedestrian Crashes



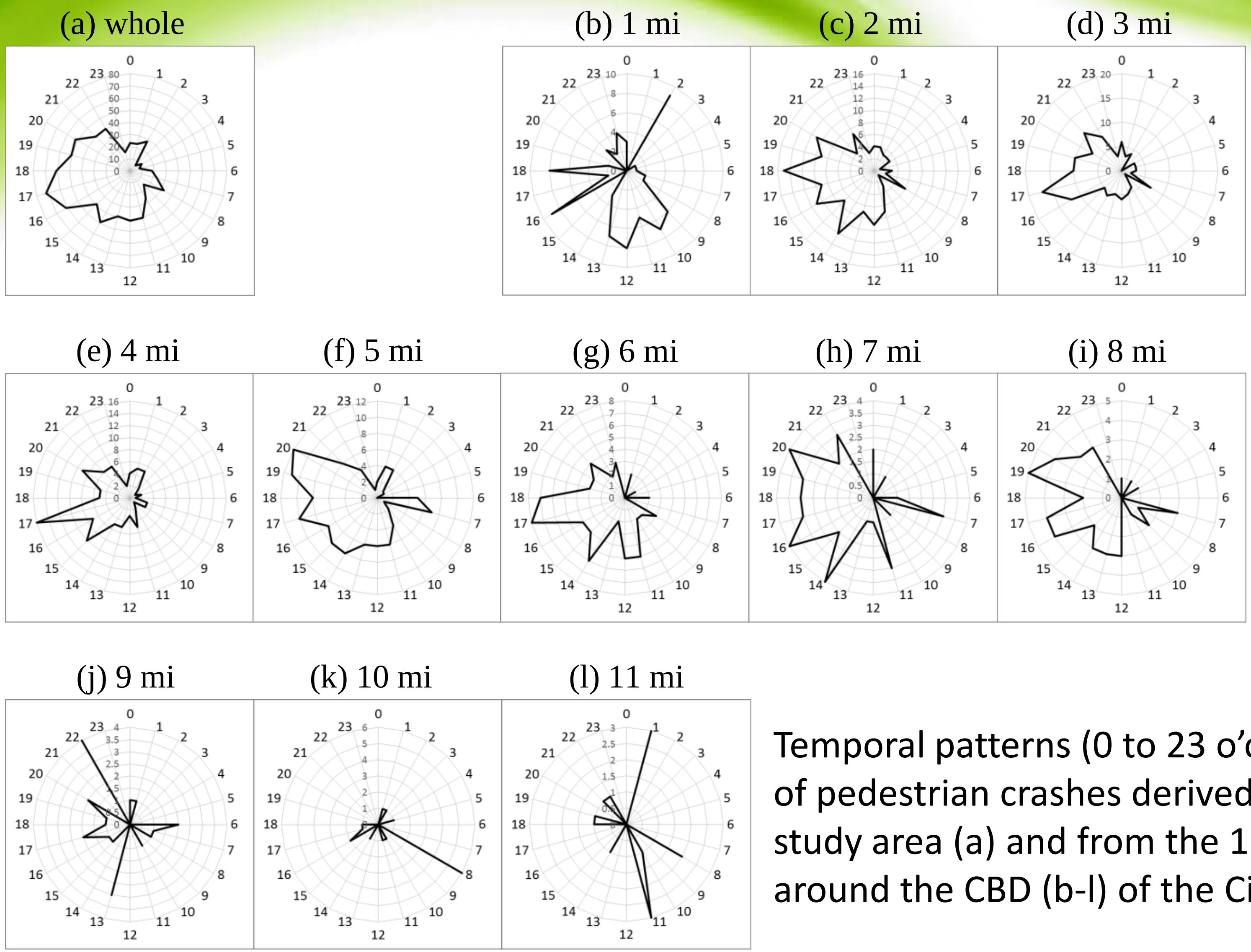
Spatial trend of pedestrian crashes derived from the 11 analysis rings around the CBD of the City of Greensboro

Results – Spatial Pattern of Pedestrian Crashes



Relationship between number of pedestrian crashes and %impervious surface derived from the 11 analysis rings around the CBD. The yellow arrow notes the relationship within the first ring (i.e. within a mile of the CBD)

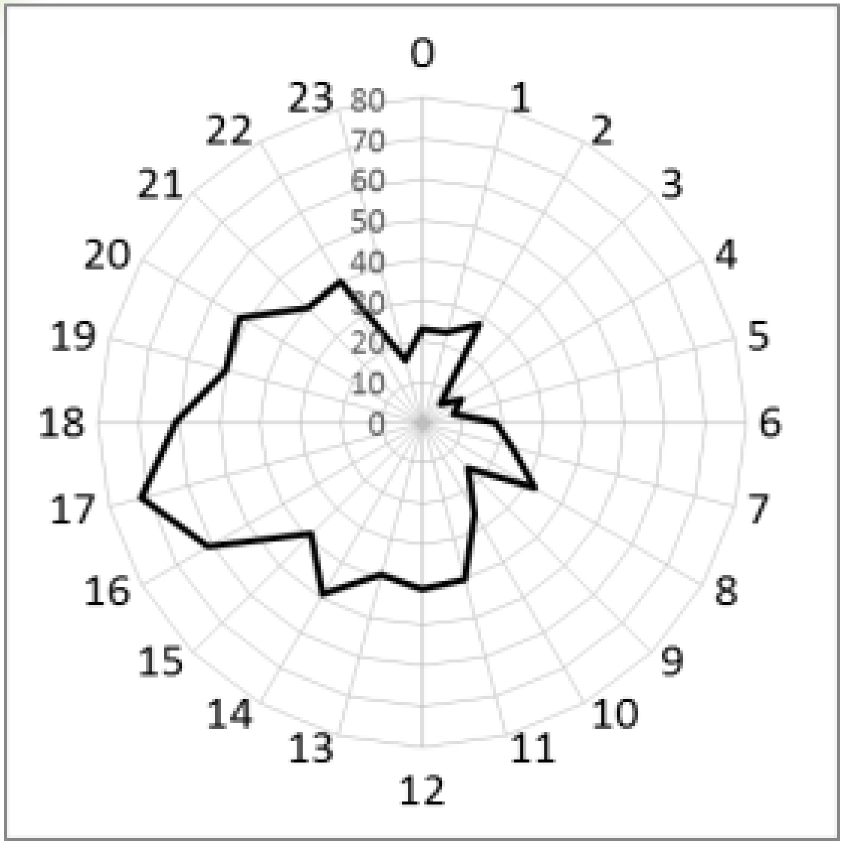
Results – Temporal Pattern of Pedestrian Crashes



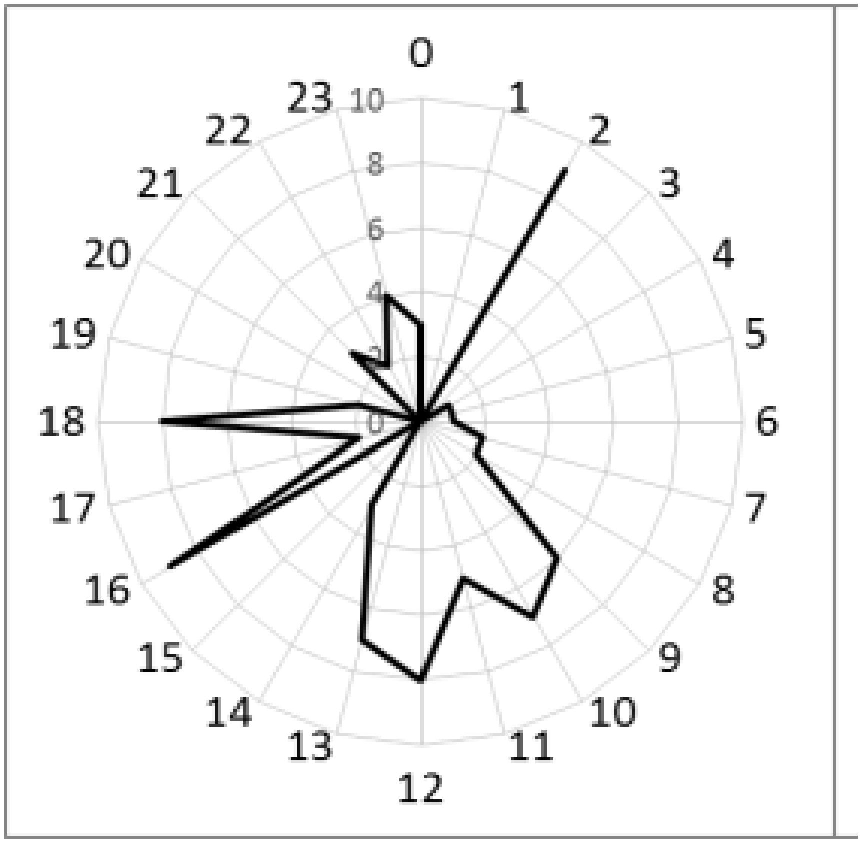
Temporal patterns (0 to 23 o’clock) of number of pedestrian crashes derived from the whole study area (a) and from the 11 analysis rings around the CBD (b-l) of the City of Greensboro

Results – Temporal Pattern of Pedestrian Crashes

(a) whole



(b) 1 mi



Results – Pedestrian Crash Factors

Ordered probit model results for all rings combined (overall column) and each analysis ring (other columns) around the CBD

******Only significant variables (p≤0.05) are shown in this table.*

******Results for rings 7-11 are not presented because there was no significant result for these 5 rings*

Independent variables	Overall	Analysis rings					
		1 mile	2 miles	3 miles	4 miles	5 miles	6 miles
1. Pedestrian characteristics							
Gender							
Male				1.3		1.2	
Female							
Age							
15 or younger							
16-64						-3.2	
65 or older						-4.6	6.3
Race							
Asian				-6.2	3.1		
Hispanic	-1.2			-7.0			
White				-8.1			
Black	-1.0			-8.5			
Native American							
Other	-1.4						
2. Driver Characteristics							
Gender							
Male		2.0			0.8		
Female							
Age							
15 or younger							-13.1
16-64							
65 or older		-2.7					
Race							
Asian					-3.2		
Hispanic							
White		-2.2					
Black							-9.4
Native American							
Other							
Alcohol/ Drug Use							
Yes			1.0				
No							
Vehicle Type							
Truck			-5.2				
Bus							
Light truck							-5.3
Car	-0.4			-1.5			-4.5
Motorcycle							
Other							
3. Environmental Conditions							
Location							
Intersection	0.4					4.2	
Intersection-Related				1.8		2.8	
Non-Intersection	0.4			1.3		1.7	
Weekday							
Weekday		-2.3					
Hour							
Midnight – 2:59 a.m.							
3 a.m. – 5:59 a.m.	0.6		2.6	2.1			
6 a.m. – 8:59 a.m.		-9.2					
9 a.m. – 11:59 a.m.		-7.0					
noon – 2:59 p.m.		-6.6					
3 p.m. – 5:59 p.m.	0.6			2.0			
6 p.m. – 8:59 p.m.							
Weather Condition							
Snow, Sleet, Hail, Freezing Rain/Drizzle							
Rain							
Fog, Smog, Smoke							
Cloudy					8.2		
Clear					7.7		
Light Condition							
Dark - Unknown Lighting							
Dark - Roadway Not Lighted							
Dark - Lighted Roadway				2.0			
Dusk-Dawn							
Daylight					-5.6		
Other							
4. Network Variables							
Number of Lanes							
1 lane	0.4	-6.1					
2 lanes							
3 or more			-1.4				
Road Characteristics							
Curve - Hillcrest					7.0		
Curve - Grade					9.9		
Curve - Level					8.8		
Straight - Hillcrest					6.9	-8.3	
Straight - Grade					7.3	-5.6	
Straight - Level					7.1		
Straight - Bottom							
Other							
Road Configuration							
Two-Way, Not Divided							
Two-Way, Divided, Unprotected Median	0.7						
Two-Way, Divided, Positive Median Barrier	1.1					3.2	
One-Way, Not Divided							
Road Surface							
Coarse Asphalt		-10.7					
Smooth Asphalt		-14.0					
Grooved Concrete							
Concrete		-14.5			-3.8		
Gravel				3.9			
Soil							
Other							
Traffic Control							
No Control Present						3.1	
Human Control	-1.7						
Double Yellow Line, No Passing Zone							
School Zone Signs							
Warning Sign							
Yield Sign							
Stop Sign		-6.4					
Flashing Stop And Go Signal	-1.4						
Stop And Go Signal							

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Discussions

- Strong quadratic relationship between proportion of impervious surface and number of pedestrian crashes because
- high degree of urbanization is correlated with high proportion of impervious surface;
- an increase of impervious surface indicates the increase of not only sidewalks and rooftops but also parking lots, driveways, and roads where pedestrian crashes are often occur;
- within the city center, low crashes are associated with congestion, increase in driver awareness of pedestrians, decrease in aggressive behavior of drivers due to narrow roads and high buildings, and traffic controls.

Discussions (cont.)

- Factors explaining pedestrian crash severity may not be the same along the urbanization gradient of the city.
- Many of these factors are expected and in concert with current literature. However, some factors are counter-intuitive.

Discussion (cont.)

- Successful utilization of both satellite – based imagery data and crash data to investigate pedestrian crashes in space and time.

Future Studies

- Expand the study period to better understand whether the spatial and temporal patterns are consistent over a longer time period.
- Expand the study area to include more cities to examine the effect of urbanization on crash factors at a larger scale.

Publication

TRB 95th Annual Meeting:

16-4521 Characterizing Pedestrian Crashes Along an Urbanization Gradient: A Case Study in Greensboro, North Carolina

Thank you!

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