DEVELOPING DECISION SUPPORT TOOLS FOR THE IMPLEMENTATION OF BICYCLE AND PEDESTRIAN SAFETY STRATEGIES

Deo Chimba, PhD., P.E., PTOE
Associate Professor
Civil Engineering Department
Tennessee State University
3500 John A. Merritt Blvd, Nashville, TN 37209
Phone: 615-963-5430
Email: dchimba@tnstate.edu

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STATEMENT OF THE PROBLEM

- Tennessee Department of Transportation (TDOT) has an extensive road safety audit program which uses criteria based on the ratio of crashes to average daily traffic but does not target locations with a high number of bike/pedestrians crashes since there are no bicycle and pedestrian counts.
- A robust methodology is not currently available to identify bicycle and pedestrian high-crash locations in Tennessee.
- The challenge is allocating funds, from TDOT's Highway Safety Improvement Program (HSIP), equitably among rural and urban areas in a way that is most effective at reducing bicycle and pedestrian fatalities and incapacitating injuries.

Research Questions?

- Are there spatial variations in pedestrian and bicycle crashes?
- How do spatial variations in pedestrian and bicycle crashes associate with socioeconomic and demographic factors?
- What framework can be adopted to implement bicycle and pedestrian safety strategies?

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Develop Data-Driven Policy Framework

- Develop criteria and conditions for the systematic identification of bicycle and pedestrian high-crash locations in the state.
- These criteria will rate each crash-prone location based on injuries and fatalities, coupled with exposure.
- Develop a systematic framework and rating system for future years' so that the analysis can be replicated in the future with less effort.
- Prioritize funding for improvements. To support the development of a data-driven draft policy for prioritizing and maximizing the effectiveness of HSIP fund allocation.
- The policy framework will be developed with the support of TDOT staff.
- This policy framework will direct current and future decision makers at TDOT and other agencies in the prioritization of funding.

Study Approach

- Developed a framework to identify bicycle and pedestrian high crash locations for safety improvement prioritization focusing on Population, Demographic and Socioeconomic Spectra in Tennessee
- Research approach comprised in-depth analysis using a combination of existing data, literature review, GIS, cluster analysis, and advanced statistical modeling to examine and identify bicycle and pedestrian high-crash locations.
- Relevant data from each of the selected study locations was integrated into a Geographic Information System (GIS).
- The data included crashes, roadway geometry, population, demographics and economic, and traffic.
- The study used the gathered data and information to develop safety performance functions (SPF) to identify magnitude and characteristics of variables associated with pedestrian and bicycle safety hazardous locations (black spots).
- From the SPF, the research developed tool to evaluate the expected number of crashes at block and county levels for given set of population, demographics and socioeconomic data in Tennessee

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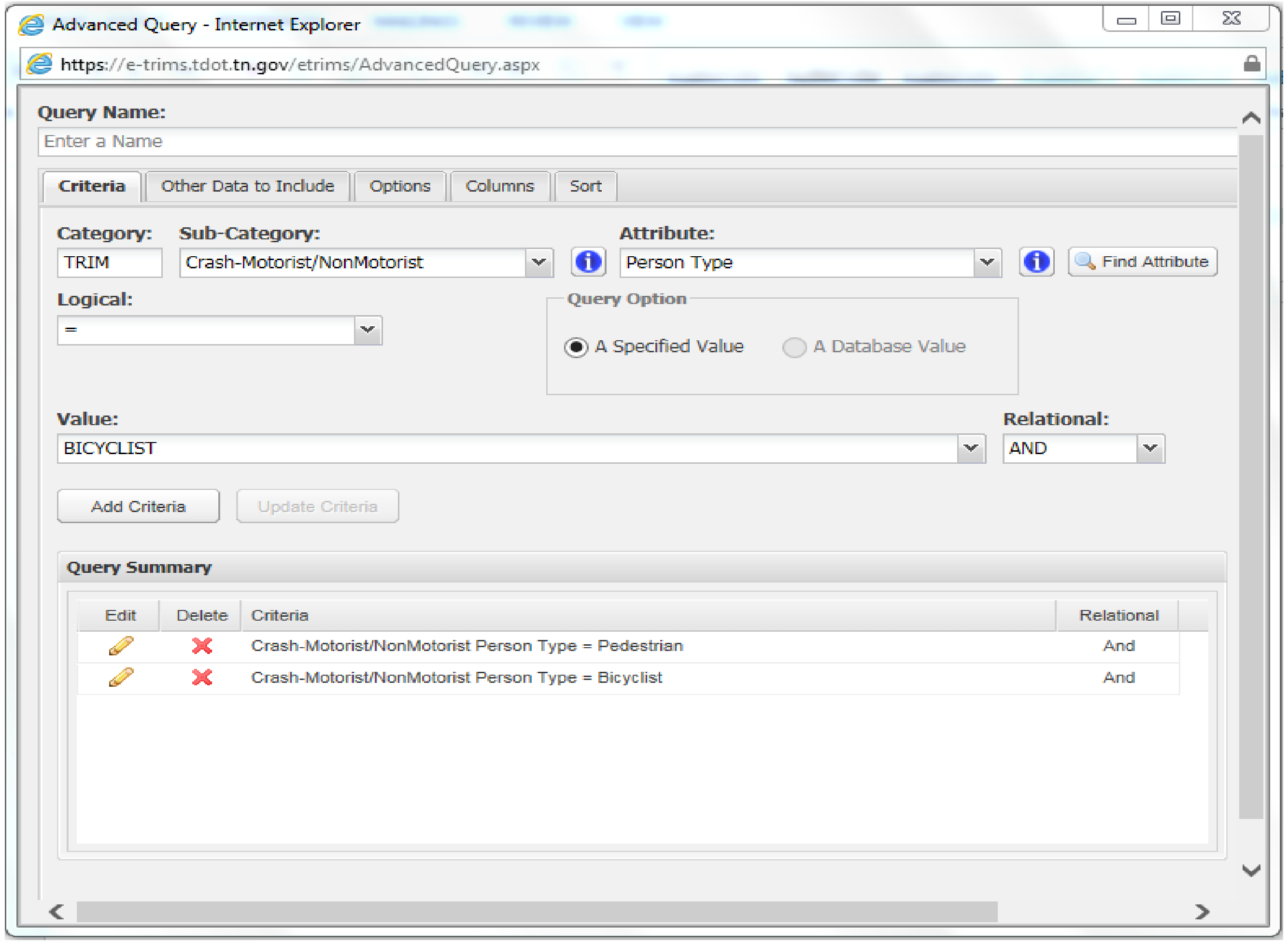
Data

Three types of data were used;

- Crash data
- Socioeconomic data
- Demographic data

TDOT Crash Database-TRIMS



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Socioeconomic and Demographic data

- **TIGER Products**

(**T**opological **I**ntegrated **G**eographic **E**ncoding and **R**eferencing**)**

- https://www.census.gov/geo/maps-data/data/tiger-data.html

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Data

Crash data

- Obtained from TDOT traffic crash database
- **5** years **2008-2012** data: **5,845** pedestrian crash records
- **5** years **2008-2012** data: **2,185** bicycle crash records

Socioeconomic data

- US census bureau,**2006-2010** America Community Survey
- **Block group** data for Tennessee
- Income, Car ownership, poverty status, Transport mode to work

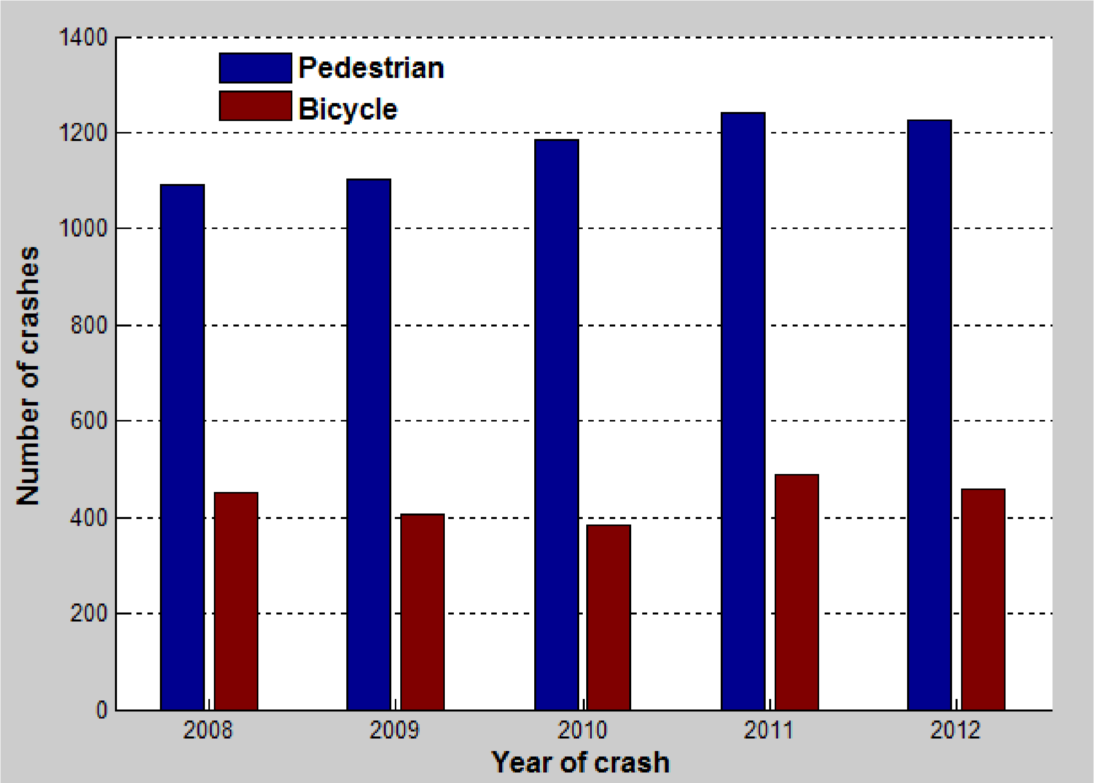
Demographic data

- US census bureau,**2006-2010** America Community Survey
- **Block group** data for Tennessee
- Population counts, age , race

Crash Data Statistics

Year of Crash	Pedestrian	Bicyclist
2008	1091	450
2009	1101	405
2010	1185	385
2011	1241	487
2012	1227	458
Grand Total	5845	2185

Type of Crash	Pedestrian	Bicyclist
Fatal	389	33
Incapacitating Injury	1109	279
Non- Incapacitating Injury	4051	1603
Prop Damage (over)	118	115
Prop Damage (under)	178	155
Grand Total	5845	2185



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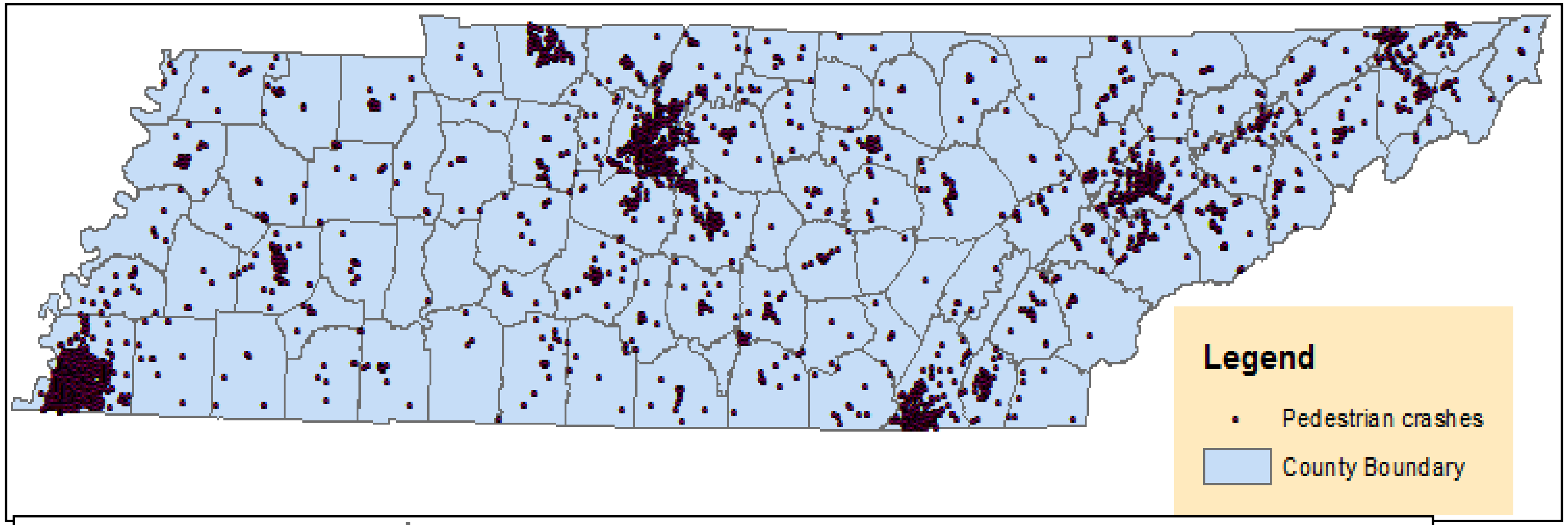
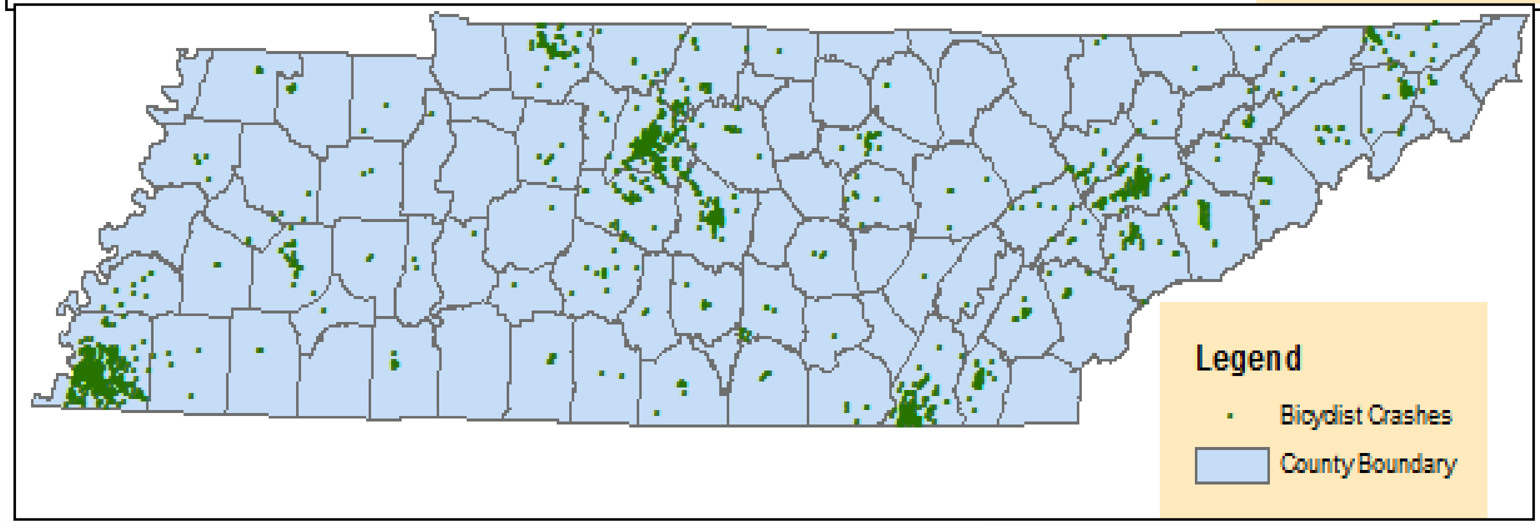
Spatial distribution of crashes





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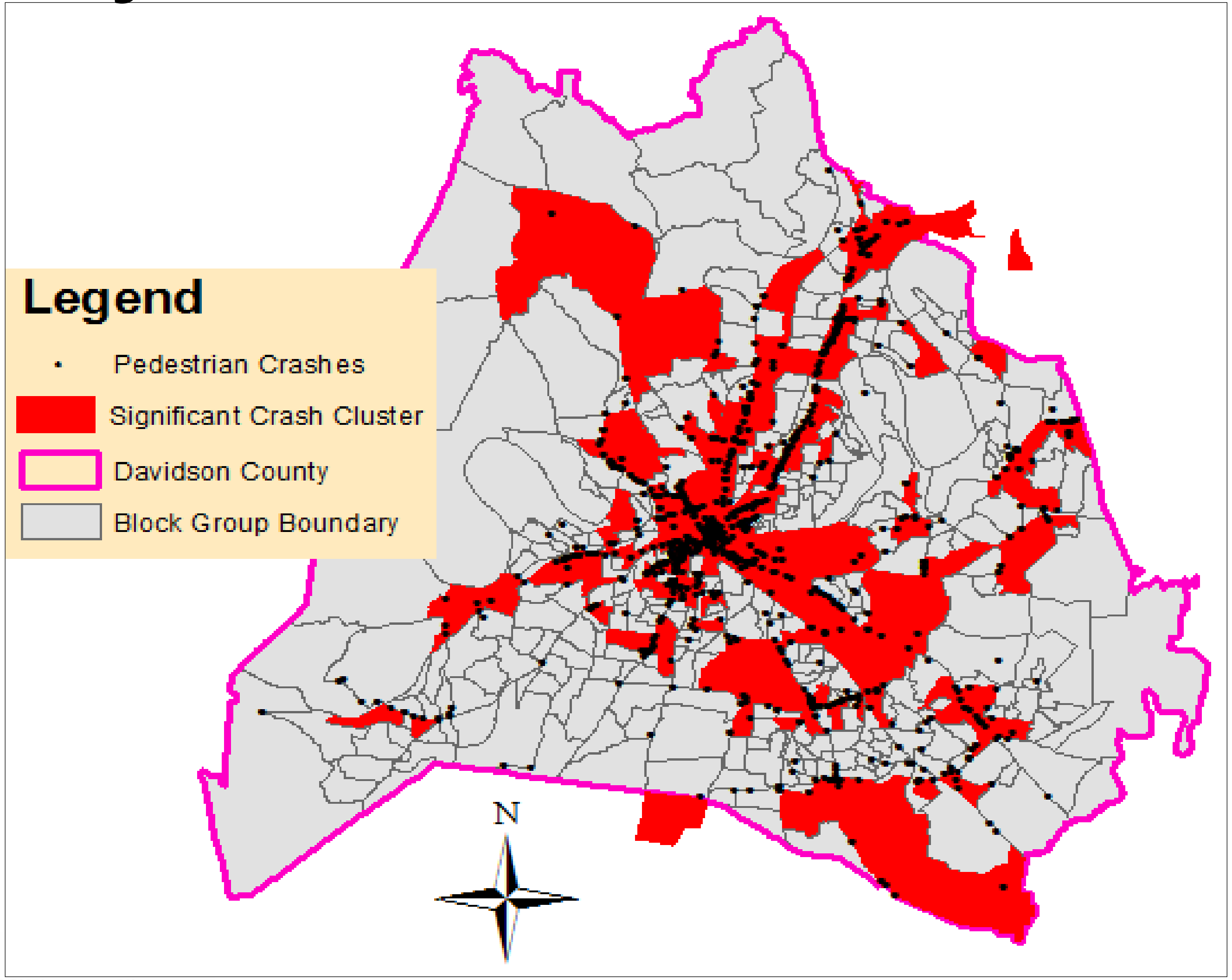
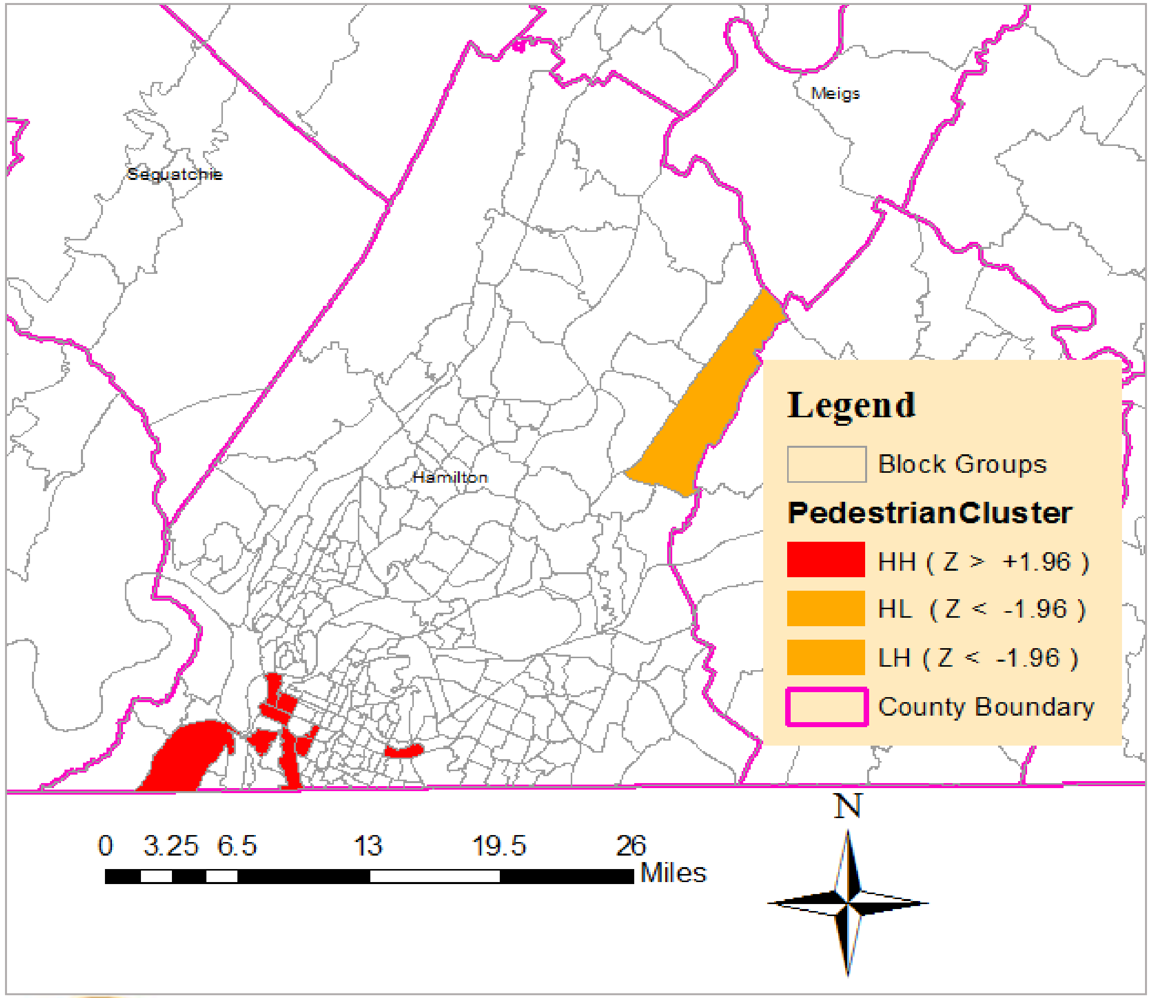
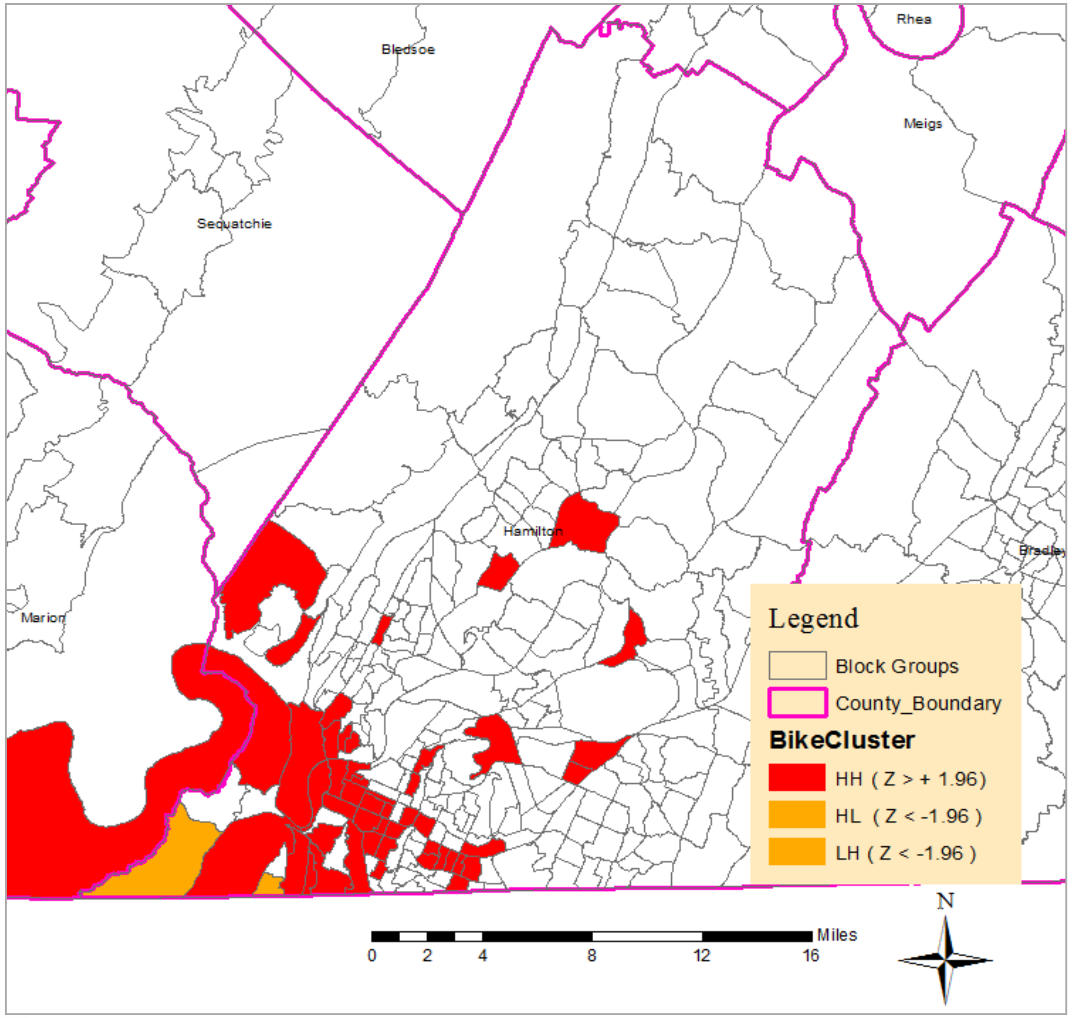
Variable	Mean	Std. Dev.	Min	Max
Population density (1000 per sq. Mile)	1.62	2.53	0.00	89.44
Population below 15 years of age (%)	19.02	7.76	0.00	59.33
Population from 15 to 64 years of age (%)	66.98	8.36	11.80	100.00
Population commuting to work by private cars (%)	95.84	5.81	0.00	100.00
Population commuting to work by walking (%)	0.83	2.89	0.00	100.00
Median household income ("000" $)	45.42	24.35	0.00	247.36
Housing units with no vehicles (%)	6.94	9.47	0.00	83.97

Cluster Analysis



Cluster Analysis





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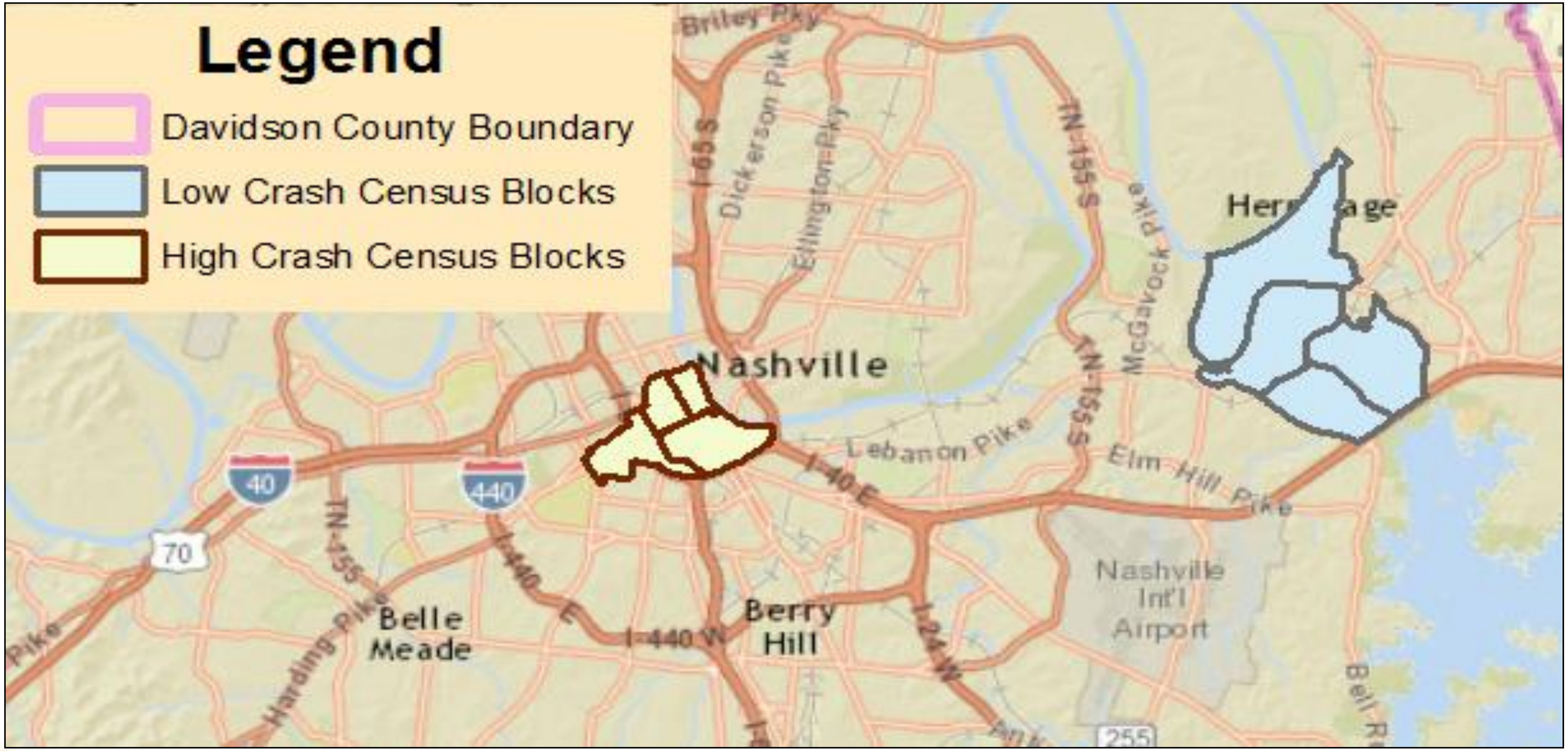
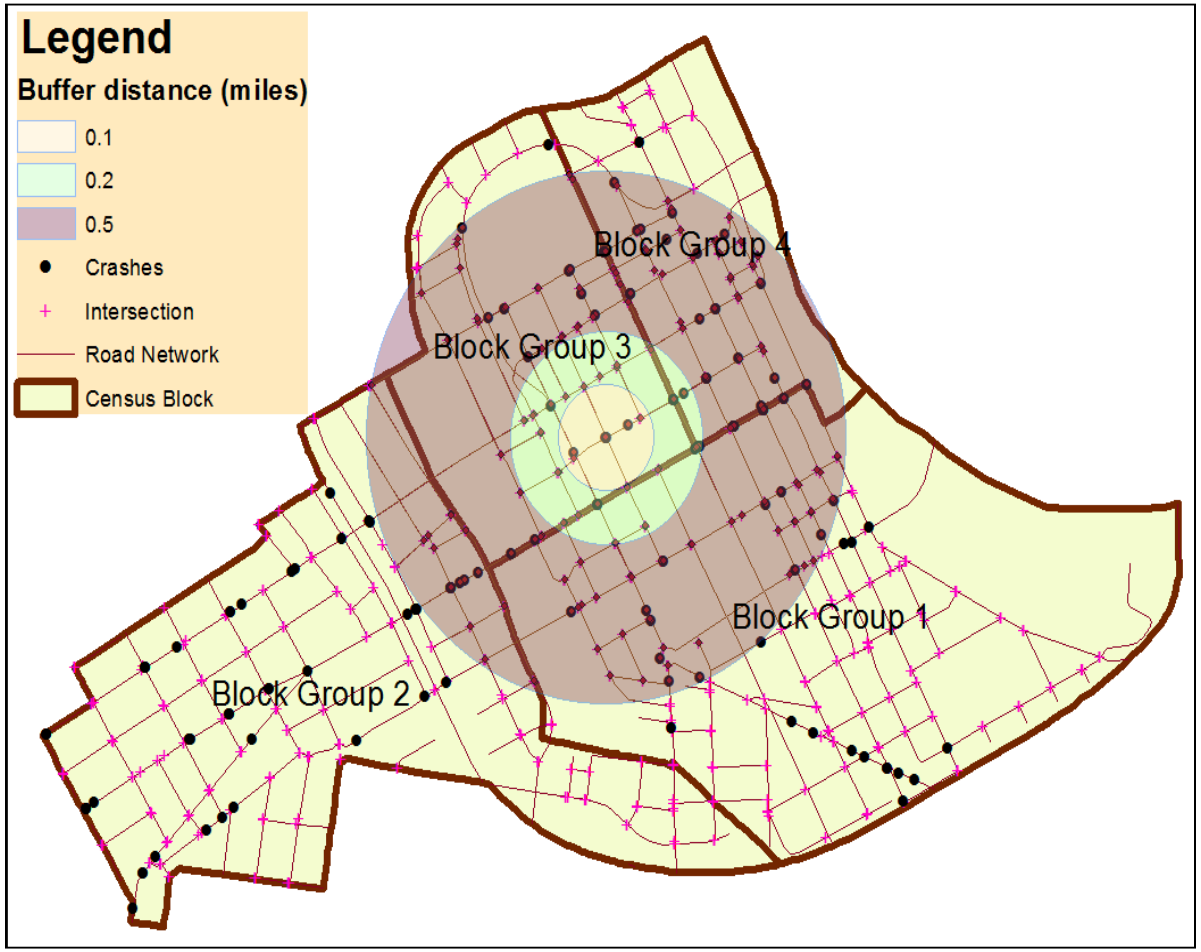
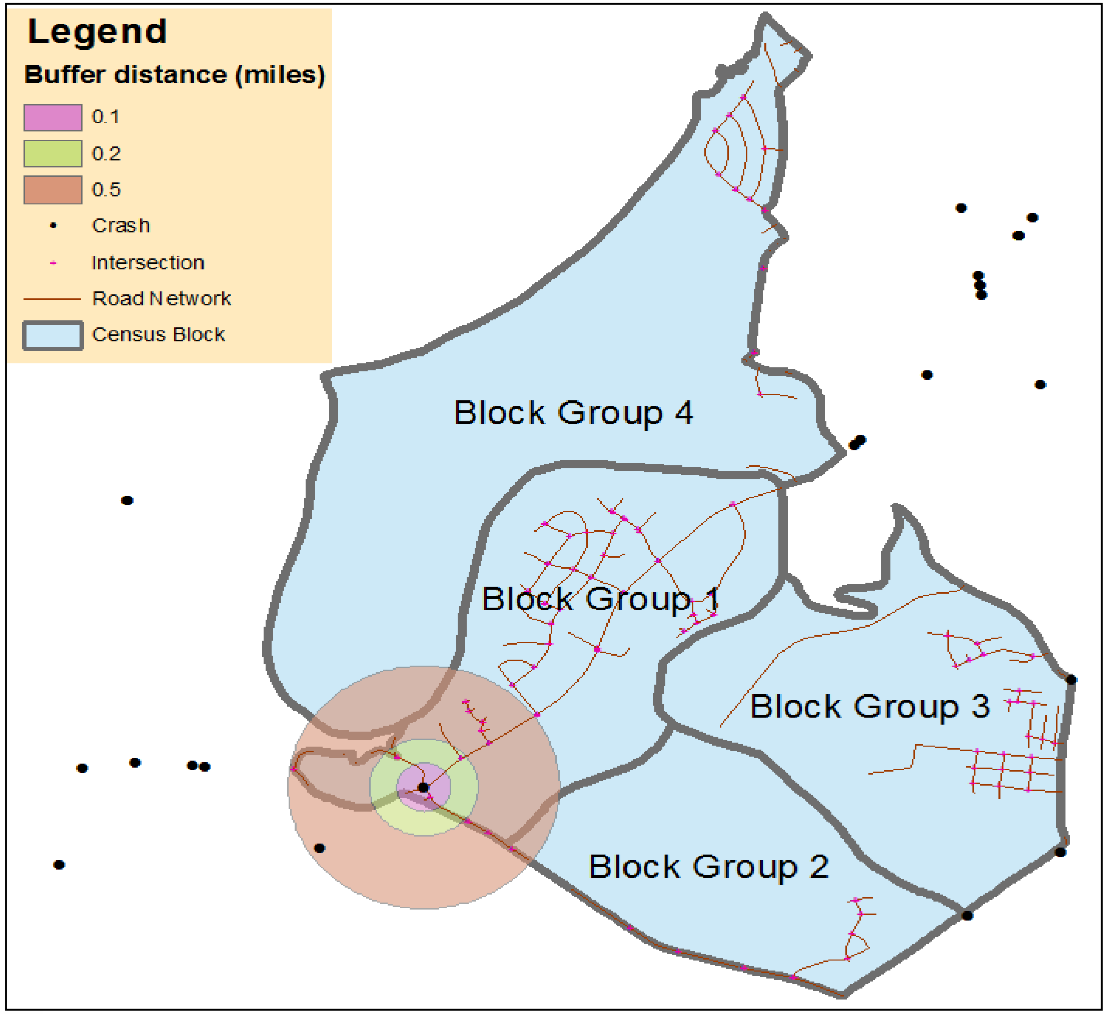
Where are high risk census block groups?



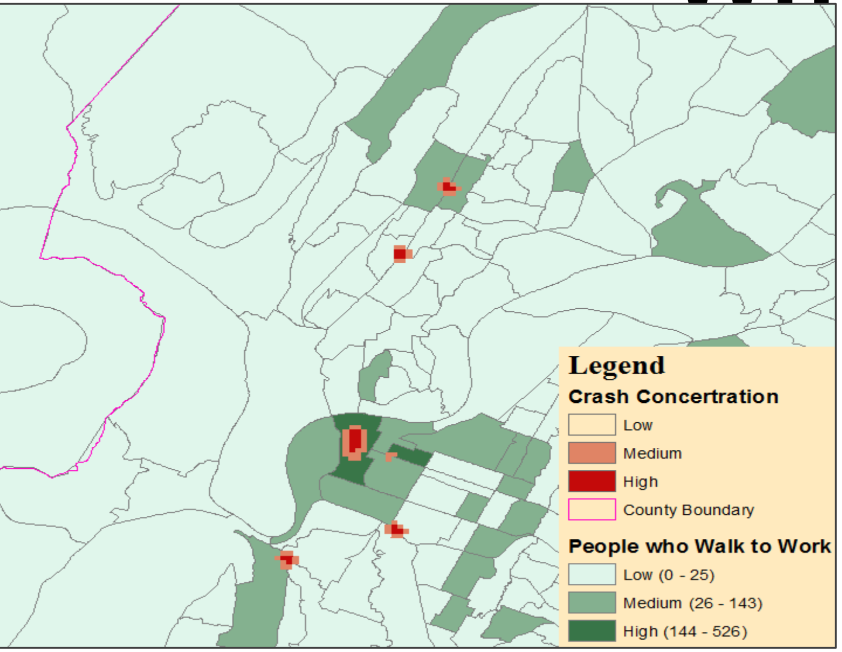
High crash census block groups

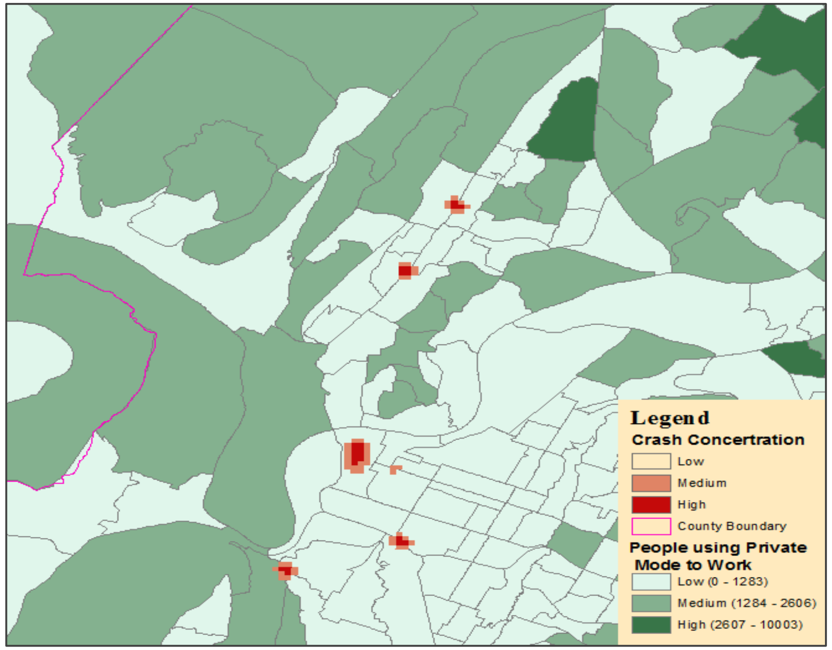


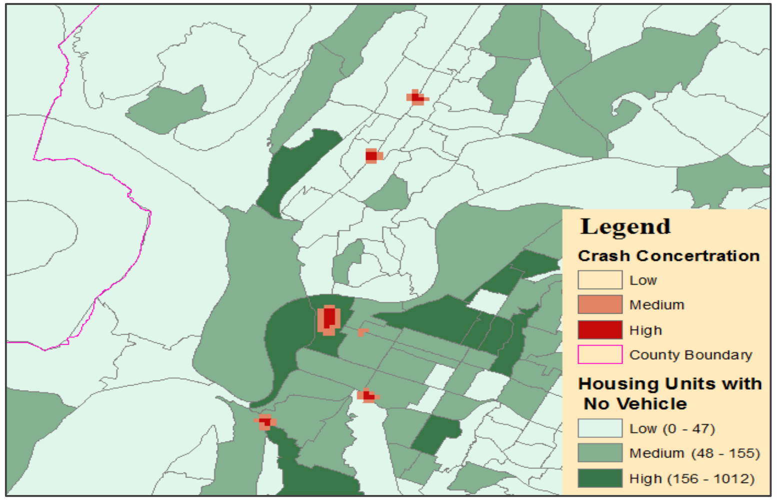
High crash census block groups

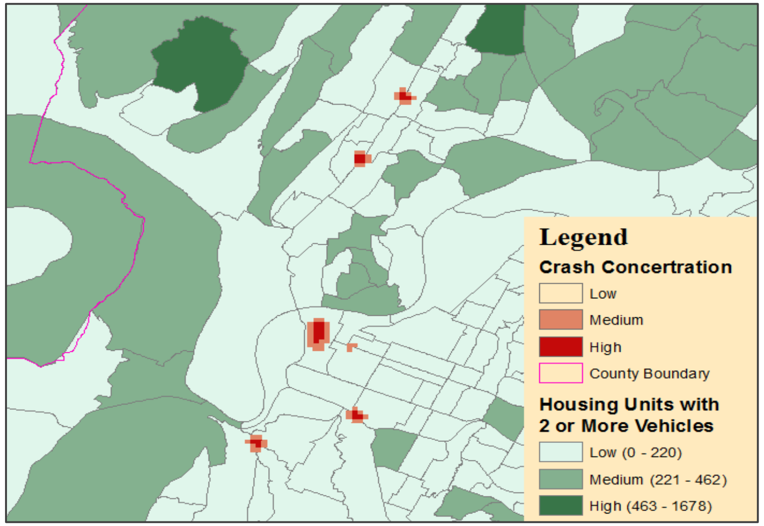


Where are these clusters?









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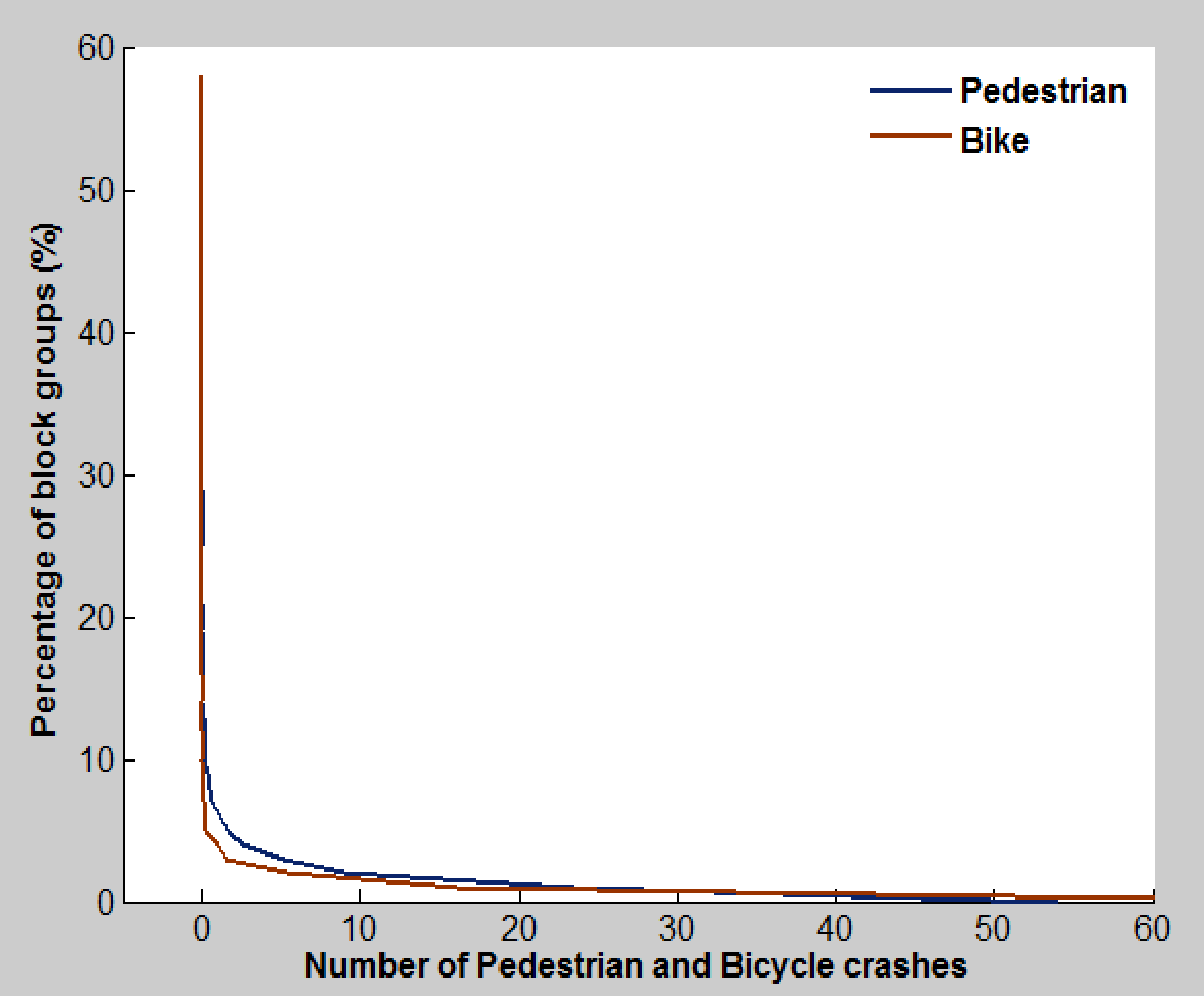

Pedestrian
Bike
Percentage of block groups (%)
Number of Pedestrian and Bicycle crashes
0
10
20
30
40
50
60

Developing Safety Performance Functions (SPFs)

- y_i number of crashes occurring in a certain period at a site *i*
- λ_i is the Poisson parameter for site *i*, which is equal to site expected number of crashes at a period, $E\,(y_i)$.
- Poisson assumes the **mean =Variance**

Poisson

$$P(y_i) = \frac{exp(-\lambda_i) * \lambda_i^{y_i}}{y_i!}$$

Negative Binomial

- For crash data the **mean ≠ Variance**
- VAR $(y_i) > E\,(y_i)$ — Overdispersion
- *α is* the overdispersion factor
- μ is the mean of crashes

$$P(y) = \frac{\tau(y+\alpha^{-1})}{\tau(\alpha^{-1})\tau(y+1)} \left[\frac{1}{1+\alpha\mu}\right]^{1/\alpha} \left[\frac{\alpha\mu}{1+\alpha\mu}\right]^{y}$$

$$\mu = E(y_i) = \exp\,(X_i\beta)$$

Pedestrian Crashes
What are the associated factors-Block Group?

Variable	Coefficient	Z	p-value
Population density (1000 per sq. mile)	0.117	7.77	0.000
Population below 15 years of age (%)	-0.008	-2.08	0.037
Population from 15 to 64 years of age (%)	0.014	3.76	0.000
Population commuting to work by private cars (%)	-0.038	-7.12	0.000
Population commuting to work by walking (%)	0.0298	2.34	0.019
Median household income ("000" $)	-0.0108	-7.34	0.000
Housing units with no vehicles (%)	0.0308	8.86	0.000
Constant	-4.4198	-7.14	0.000
Population	Exposure		
alpha	1.586		

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What are the associated factors-County?

Variable	Coefficient	z	P-value
Population below 15 years of age (%)	-0.0281	-0.91	0.362
Population from 15 to 64 years of age (%)	0.0231	0.91	0.364
Population of White (%)	-0.0461	-2.08	0.038
Population of African American (%)	-0.0368	-1.6	0.109
Population of Hispanic (%)	0.0546	1.64	0.101
Population commuting to work by private cars (%)	-0.0705	-1.13	0.257
Population commuting to work by walking (%)	-0.2909	-1.64	0.102
Median household income ("000" $)	-0.0025	-1.91	0.056
Housing units with no vehicles (%)	0.0848	2.37	0.018
Constant	1.9170	0.3	0.768
Population	Exposure		
alpha	0.11		

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Developed Crash Prediction Model (SPF)

$$\mu = \mathrm{Exp}\,[\ln(P) - 0.028A + 0.023B - 0.046C - 0.037D + 0.055E - 0.071F - 0.291G - 0.003H + 0.085I + 1.917]$$

Where;

μ: Number of pedestrian crashes
P: Population of a County
A: Population below 15 years of age (%)
B: Population from 15 to 64 years of age (%)
C: Population of White (%)
D: Population of African American (%)
E: Population of Hispanic (%)
F: Population commuting to work by private cars (%)
G: Population commuting to work by walking (%)
H: Median household income ("000" $)
I: Housing units with no vehicles (%)

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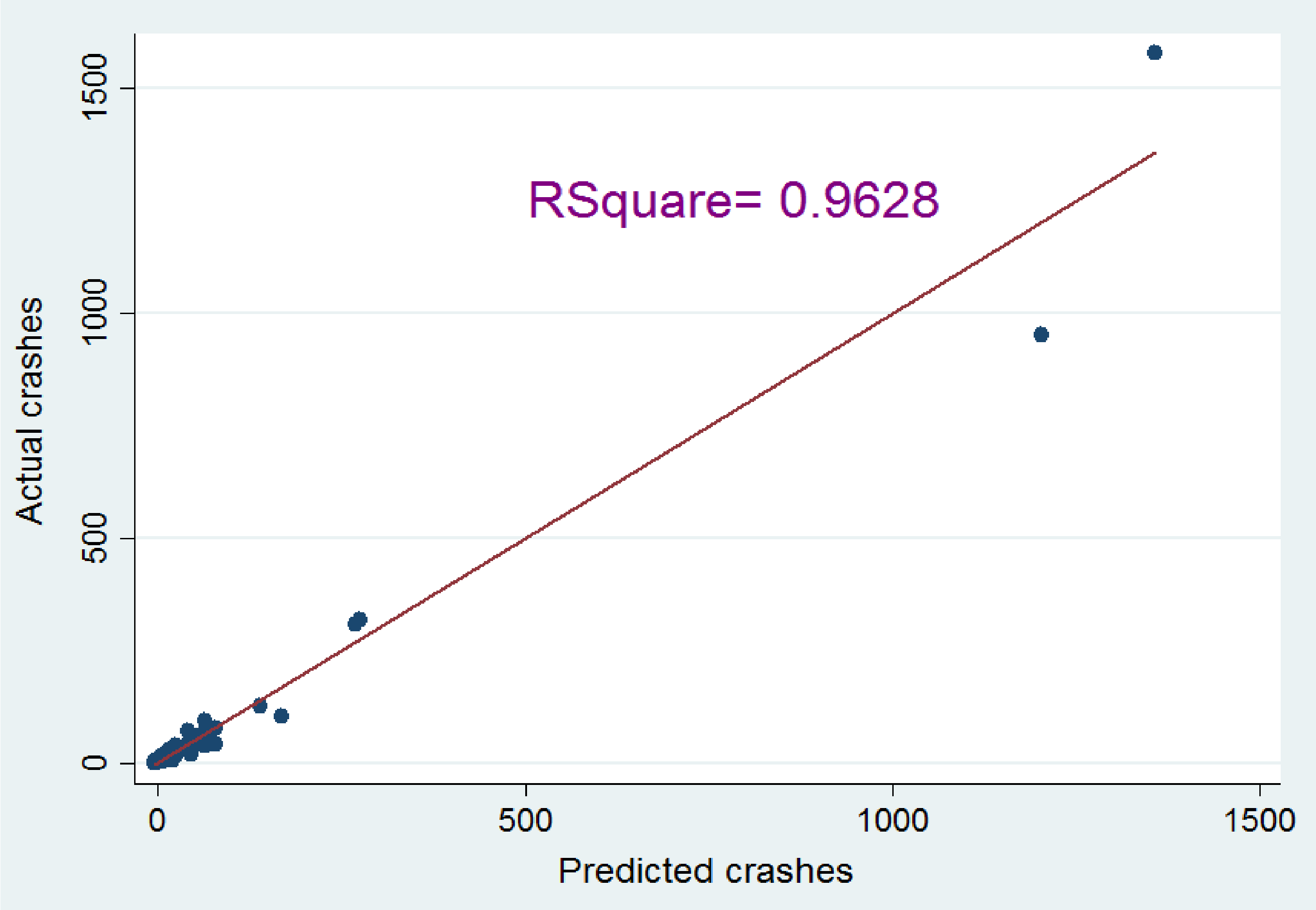
Prediction accuracy



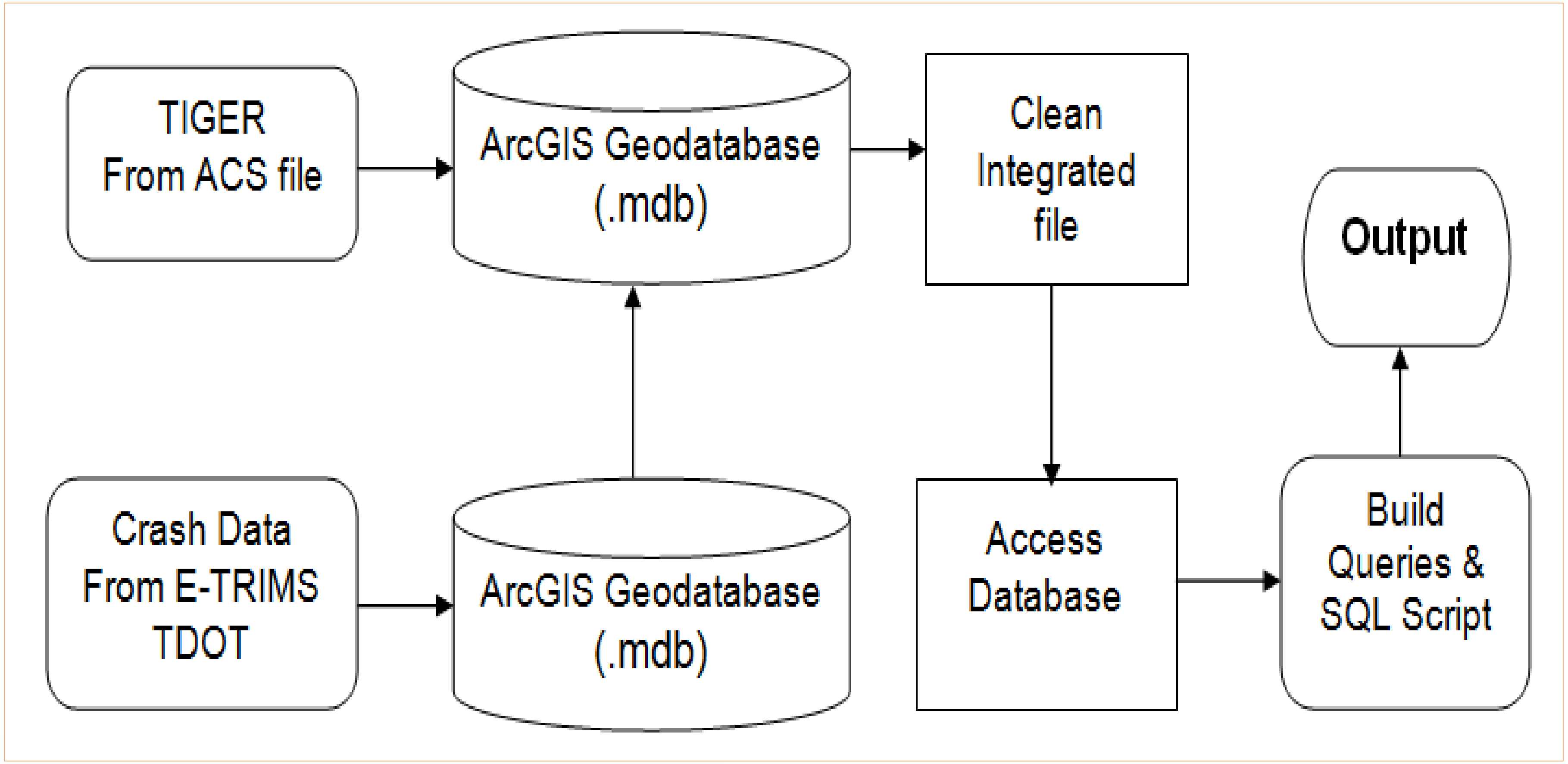
Integrating SPFs with Access Database

- **User friendly**: Unlike crash prediction models that are expressed in form of complicated equations and time consuming; this tool simplifies this process.

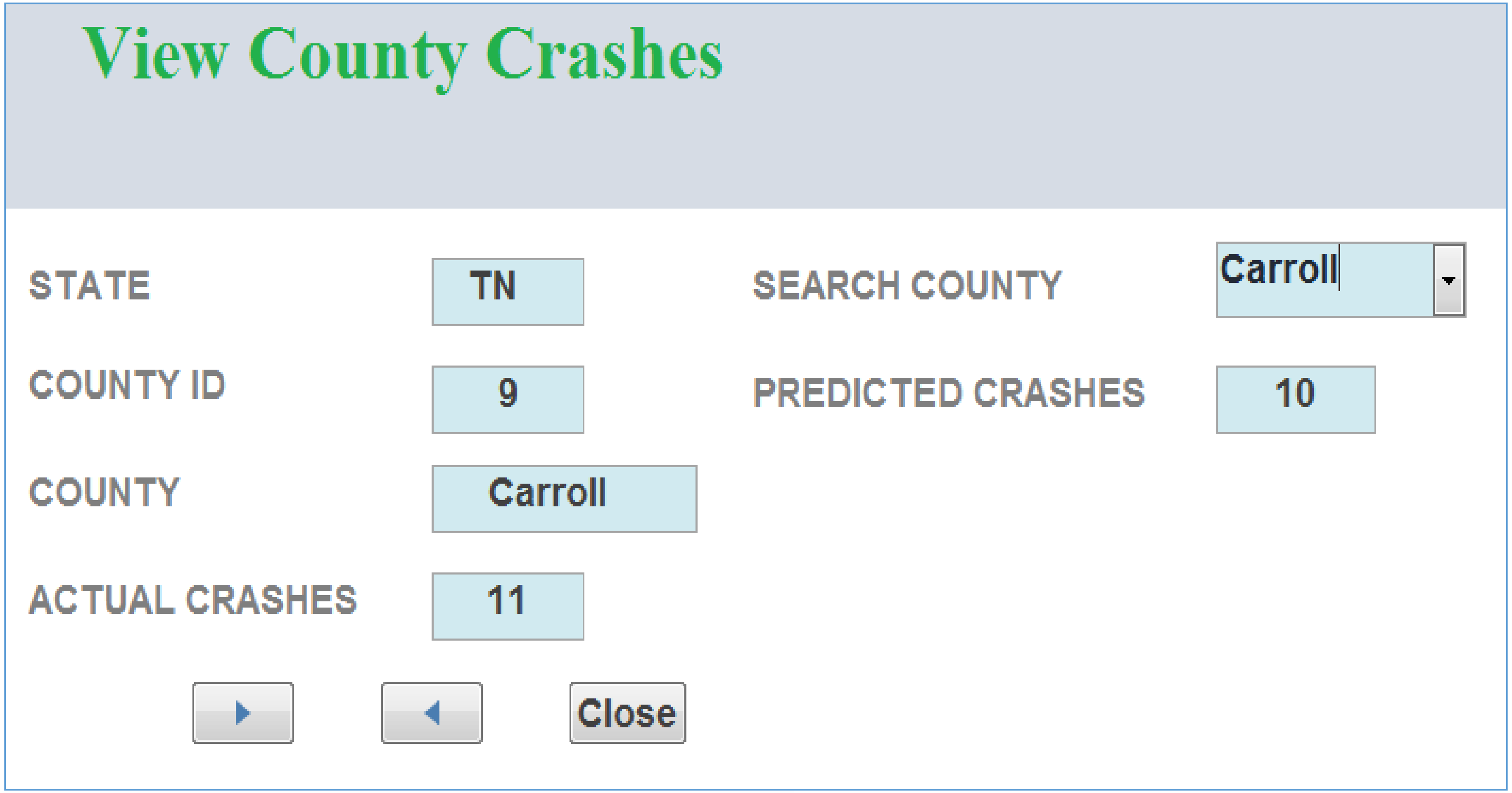
It is built in form of a database: With huge amounts of data now available, local and national agencies are now building their database.

- It helps users to gain more insight into the **relationships** between crashes and sociodemographic factors by varying the values of contributing factors.

Flow Chart of the Decision Support Tool



Interface of Decision Support system



Change County Variable

SEARCH COUNTY: Carroll REFRESH

STATE	TN
COUNTY	Carroll
POPULATION	28644
POPULATION WITH AGE < 15 (%)	18.3
POPILATION WITH AGE FROM 15 TO 64 (%)	64.2
POPULATION OF WHITE (%)	84.7
POPULATION OF BLACK (%)	9.9
POPULATION OF HISPANIC (%)	1.9
POPULATION COMMUTING TO WORK BY PRIVATE MODE (%)	98.2
POPULATION COMMUTING TO WORK BY WALKING (%)	0.5
MEDIAN HOUSEHOLD INCOME ("000" $)	36
HOUSING UNITS WITHOUT VEHICLES (%)	5.8

Let’s look at it

[..\TOOL\Decision Support Tool.accdb]

Applications?

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Conclusions and Recommendations

❖Implement design practices that accommodate Pedestrian and bicycle needs;

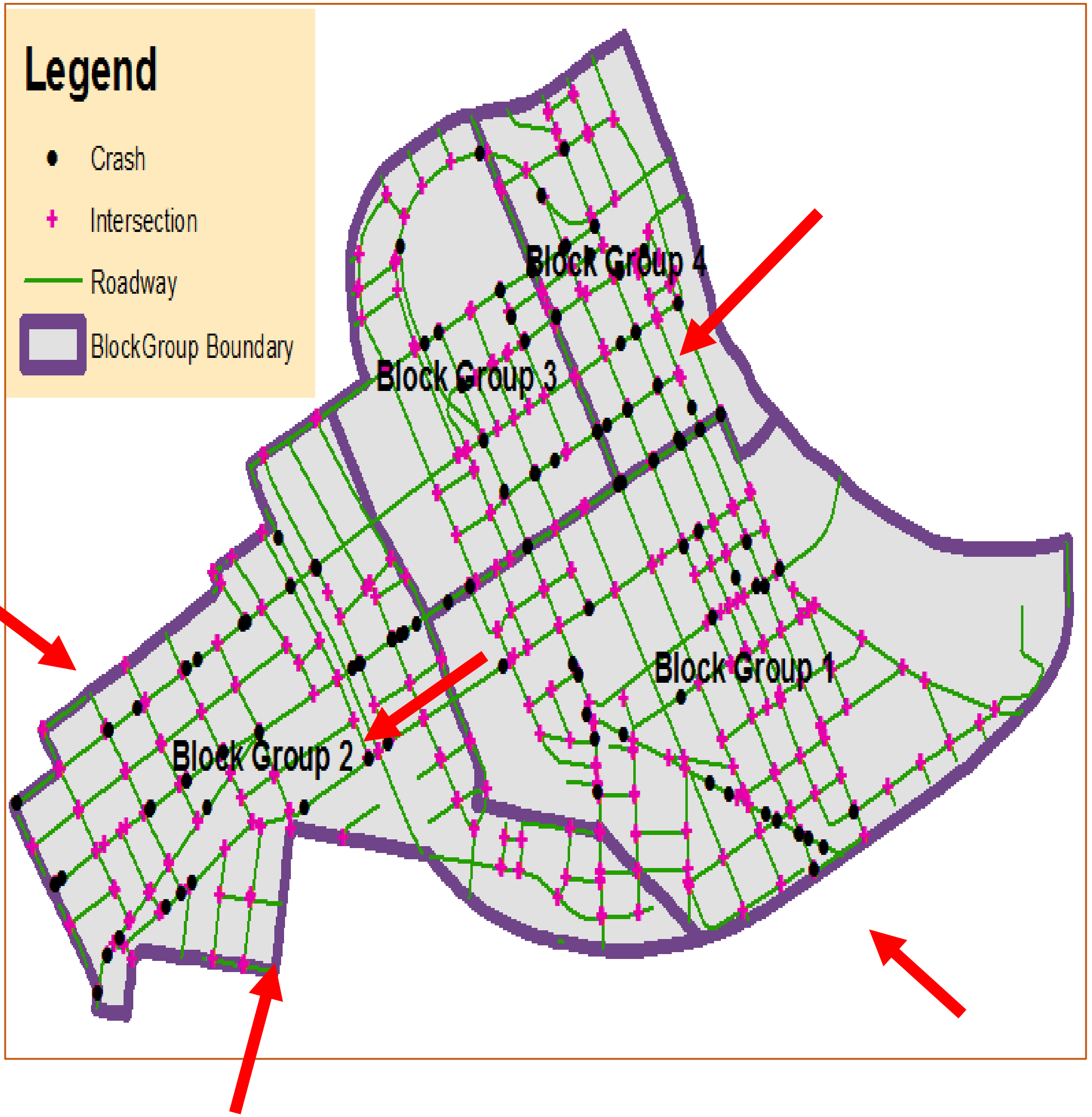
- Sidewalks
- Bike lanes
- Shared lanes

❖Reduce speeds on;

- Roadways serving as boundaries of Block groups
- Roadways crossing high crash Block groups
- Shared lanes
- School speed limits*

❖Future direction:

- Consider more variables; Roadway, Vehicle, Driver
- Collect actual pedestrian volumes
- Represent resulting crashes on map



Deliverables

Conference proceedings and presentations

1. **Musinguzi, A** and Chimba, D. “Spatial variation in local road pedestrian and bicycle crashes”. Presented and published in proceedings of ESRI International User annual Conference, San Diego, CA, 7/21/2015.

2. **Musinguzi, A** and Chimba, D. “Using Spatial Statistical Tools to correlate Bicycle and Pedestrian Crashes with Socio-demographics”. *Presented at “TSU 37th Annual University-Wide Research Symposium, 2015; 4/2/2015”*

3. **Musinguzi, A** and Chimba, D. “Bayesian logistic regression analysis of socioeconomic and demographic factors and pedestrian crash counts”. *Presented at “ Southern District ITE Annual Meeting, MS, 4/19/ 2015”*

4. Kidando, E, **Musinguzi, A** and Chimba, D. “Bayesian hierarchical analysis of pedestrian crashes and socio-demographic factors” Presented at the 2nd Summer Conference on Livable Communities, Kalamazoo, MI, 7/23/2015. ***Award of best Student poster presentation***

5. **Musinguzi, A** and Chimba, D. “An Access-Based Decision Support Tool for Assessing Bicycle and Pedestrian Safety”. *Presented at “TSU 38th Annual University-Wide Research Symposium, 2016*

Papers under peer review

7. **Musinguzi , A** and Chimba D. “Using kernel density to evaluate dependence of pedestrian crashes on demographic and socioeconomic factors”.

8. **Musinguzi, A** and Chimba, D “Adaptive neuro-fuzzy inference system (ANFIS) approach for pedestrian injury analysis”.

9. **Musinguzi, A**, Chimba, D and Kidando, E. “A Regression-Bayesian network hybrid approach for pedestrian injury analysis”.

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